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SKETCHES FROM THE GREAT EXHIBITION.

THE LIFE-SAVING SERVICE.

Upon the shore of the lake, near the United States Department, is a United States Life-Saving Station; not placed there in view of the dangerous character of the various inventions exhibited upon the lake, but an exhibit of a *bona-fide* life-saving station, with boats and apparatus, in all of their details and arrangements complete, as used and supplied at the various stations upon the coast.

The loss of life by shipwreck has always been a terror to mankind; men who would boldly face the heaviest artillery quail before the dangers of the sea, and as a natural sequence there have been many inventions and methods devised for saving life when endangered by water.

Some of these have done good service in years gone by, and on the English coast a great deal has been done within the century, but upon the American coast no especial attempt in that direction was made by the government until 1850. Previous to that time the revenue cutters were, as now, on the alert to aid distressed vessels and save life in all cases where

they could be of service, and in many cases they and their crews have received well-merited and substantial commendation and rewards from our own and other governments for services rendered.

In 1850 some small houses were erected at points on the coasts of Long Island and New-Jersey where the coast line is mostly a long, barren, and nearly uninhabited strip of land, and where shipwrecked men were in great danger of starvation even if they reached the land; while the numbers of comparatively helpless women and children brought into Sandy Hook by the passenger ships made opportunity for some of the most appalling disasters upon record. And we are shown here *the first shot ever fired to save life upon the American coast.* This shot is shown in the accompanying sketch as the "Ayrshire" shot. It is a thirty-two pound ball (about five and a quarter inches in diameter), with the score and bar to which were attached the lines carried by this shot from the shore on board of the ship Ayrshire, when stranded upon Squan Beach, New Jersey, on the 12th of January, 1850.

The line carried by this shot established communication with the shore, and by the assistance thus rendered the life-car invented by Captain Ottinger, U. S. R. M., was drawn on board, and 201 lives were saved. This was the first occasion on which the life-car was used, and Captain Ottinger received, by vote of the then Congress, the sum of $10,000 therefor. The shot lay in the hold of the wreck, covered with sand, for twenty-two years, when, by the mutations of the sea, it was washed out, and found and recognized, together with a jack-knife lost there by one who was at the wreck. It is now mounted upon a neat mahogany base, and marked with its history, a trophy of pride to the service. Its surface is somewhat corroded, but if called upon it might repeat its service yet.

ORGANIZATION OF THE LIFE-SAVING SERVICE.

At that time there was no definite organization of this service, and the only aid available on the occasion of a wreck was such of the country people as could be hastily brought together, and, as before stated, the coast being nearly uninhabited, the service was sadly deficient.

In 1854 the Powhattan was lost on the New-Jersey coast, and with her over three hundred lives. This led to some improvement: twenty-six stations were established on the coast of Long Island, and fourteen on that of New-Jersey. A superintendent was appointed for each coast, and a keeper for each station, but no provision made for crews; and in this state the service continued until 1870, when some improvement was made by the employment of six surf-men at each alternate station on the New-Jersey coast, for three months in the year.

In 1871 a thorough and comprehensive plan of organization of the service, embracing the whole of the Atlantic, Pacific, and Lake coasts of the United States, was made and carried out, mainly by the exertions of its present head, Mr. S. I. Kimball, Chief of the Bureau of Revenue Marine, who, with Captain John McGowan, U. S. R. M., Superintendent of Construction, and Captain J. H. Merryman, U. S. R. M., Superintendent of Construction and Inspector of Life-Saving Service, has charge of the life-saving service, being represented on the grounds by Lieut. W. Walton, U. S. R. M., of District No. 6 of the Life-Saving Service.

As now organized, the whole coast is divided into eleven districts, located and subdivided by stations as follows:

U.S. Life Saving Station

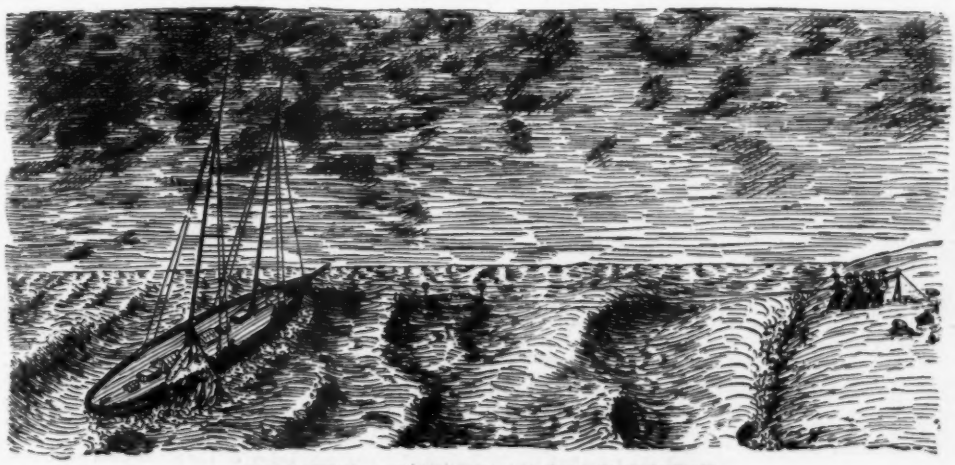
District No.	1.	Maine and New-Hampshire	6 stations.
" "	2.	Massachussetts	14 "
" "	3.	Rhode Island and Long Island	36 "
" "	4.	New-Jersey	40 "
" "	5.	Delaware, Maryland, and Virginia to Cape Charles	8 "
" "	6.	Cape Henry, Va., to Cape Hatteras, N. C.	10 "
" "	7.	Florida	5 "
" "	8.	Lakes Ontario and Erie	9 "
" "	9.	Lakes Huron and Superior	9 "
" "	10.	Lake Michigan	12 "
" "	11.	Pacific Coast	8 "

The following synopsis of details of disasters that have occurred since the reorganization of the service in 1871, upon the portion of the coast embraced in its scope of operations, will be the best evidence to the public mind of the value and efficiency of the service:

Total number of disasters	271
" " " lives imperilled	3,201
" " " " saved	3,158
Total number of lives lost	43
" " " shipwrecked persons sheltered	597
" " " days' shelter afforded	1,882
Value of property imperilled	$8,122,694
Total value of property saved	5,526,177
" " " " lost	2,560,517

In the above will be noticed the item of shelter afforded. The importance of this branch of the service will be understood by considering the fact that of those given as lives lost, one was a man from a frost-bitten crew, who reached the land by his own exertions, but, unaware of the proximity of the life-saving station and crew, who afterward saved his fellows, wandered off into the woods and perished from cold and exhaustion. This and starvation is indeed the principal danger on the Florida coast, where the shore is bold and shipwrecked crews have but little difficulty in landing, the stranded vessel being generally thrown high up on the beach. Here, therefore, the life-saving service is mostly confined to stations or houses of refuge—or, more properly, houses of succor—containing supplies and provisions, and in charge of a keeper only.

Also the apparent omission of the Gulf Coast, in the districts mentioned, arises from the fact that, owing to the nature of the bottom and sea there, stranded vessels seldom go to pieces immediately, and the crews can easily escape either in their own boats or those of passing vessels, or, by telegraphing, the revenue cutter can be obtained from the nearest port.



LIFE-SAVING APPARATUS AT THE EXHIBITION.

In the last five districts the stations are in course of construction, and in the other districts some stations are now constructing; therefore no direct comparison can be drawn at the present time between the amount of services rendered, either between the districts themselves or between different years in any one district; but the present plan of keeping detailed and accurate records of all interesting circumstances at each station, supplemented as it is by the act of Congress of June 20th, 1874—which act makes it obligatory upon those owning or commanding vessels, when casualties or accidents occur involving loss of life or damage to property to the amount of fifty dollars, to furnish in writing, through the collectors of customs, all the information they may have or that may be desired in relation thereto—will in due time give a very interesting and valuable record, and materially assist in preventing much of the loss of life and property from these causes.

PERSONNEL OF THE SERVICE.

Besides the officers already named, who have general supervision and control of the life-saving service, each district is in the immediate charge of a superintendent, appointed by the Secretary of the Treasury, and each station is in the charge of a keeper, who is captain of that crew, and is also appointed by the Secretary of the Treasury; and to such stations as it is deemed necessary are attached a crew of six surf-men employed for the season, from four to six months of the inclement time of the year. These men sign articles similar to seamen (the keepers and superintendents take an oath of office), and are selected for their courage and skill as boatmen. They are drilled regularly in the use of the various

materials of the service and management of the boats, etc. These surf-men patrol the beach from station to station every night, carrying lanterns and signals.

SIGNALS.

The signals used by the life-saving service consist of flags for day use, and rockets and Coston lights by night, and by a very simple and efficient code the stations can signal to each other, upon occasion, for assistance with very little loss of time. The Signal-Service of the army has also established its semaphores and telegraphs at some of these stations, increasing the facilities for communication.

It is also the practice to light fires and make signals to encourage the shipwrecked people while awaiting the arrival of the boats or life-cars, which have frequently to be transported for miles over the sand of the beach, on wheels, before the attempt to render assistance can really begin. The character of the assistance rendered varies with the circumstances of the case; if the state of the sea will permit, the surf-boat—a strong row-boat of pattern most approved by experience for safety in rough water—is launched, and manned by a crew of six oarsmen and one steersman, and by successive journeys from the wreck to the shore the distressed seamen are landed as soon as may be. Or if this is impossible, the mortar is used, of which several styles are shown here, including the ordinary 5½ inch mortar; a smaller one, fitted to be carried upon the back for transportation; and a German one, mounted on wheels like a field-piece; and also a gun or blunderbuss, to be used at the shoulder, and rested upon a tripod like a surveyor's compass. The object of each of these is to throw a ball, to which is attached a light line, on board of or across the stranded vessel. Sometimes for the same purpose a rocket is used, and the Boxer, or double rocket, invented especially for this use, contains a double charge, the second being ignited as the first is expended, in order to increase the distance attainable. The mortar is placed in such a position that the shot will strike on board of or beyond the wreck, carrying its line within reach of her crew. To this line is attached the end of the hawser and one block of the whip, or hauling line; the crew of the ship hauling these on board and making them fast to a mast or any strong timber, the surf-men haul the life-car on board as shown in the cut, which represents the model shown here. The car hangs from travellers that run on the hawser, and by lifting the car, in a great measure, above the action of the surf, it makes the operation comparatively easy and safe. The people of the stranded vessel are placed in the life-car and the top closed, leaving only small openings for the air, and the car is drawn ashore with even less labor than that of drawing it on board.

LIFE AND SURF BOATS.

There is seen on the lake a life-boat of the latest and most approved pattern. Her length is: keel, 24 feet; over all, 26 feet 8 inches; her extreme breadth is 7 feet 3½ inches; depth from under side of keel to upper edge of gunwale, 3½ inches; depth of keel below planks, 5 inches; sheer of gunwales, 2 feet 0½ inch; displacement, $3\frac{240}{1000}$ tons; weight of boat, $1\frac{1495}{1000}$ tons. She carries eight oars, and also two masts, with lug, fore, and main sails and staysail. Her principal peculiarity is in a double bottom: that which would properly be the lower hold being filled with cork or air chambers, and her floor being above her natural water-line, she will clear herself, if filled with water, in a short time, the water passing out by pipes and valves provided therefor. Being ballasted and provided with air-chambers under the deck, she is not only very difficult to capsize, but will, unless held, right herself, and immediately begin to clear herself of water. This boat is provided with skids and rollers, etc.; but, being too heavy for long transportation or ordinary surf-work, she is designed for harbors or breakwaters, where, being kept afloat, she can be very quickly rowed to the scene of danger.

The surf-boat is a lighter-built craft, with more sheer than the ordinary whale-boat, and a square stern. She is kept mounted on a truck, with wheels the felloes of which are six or seven inches wide, for traversing the sand hills and beaches. On arriving as near as possible to the wreck, this boat is launched, and manned with six oarsmen and a steersman. A boat of this class is kept at each station. Besides the boats there are cork jackets for the crews, and a lighter kind of car to use with the hawser, as in the cut; it is called a "breeches basket," and is a large circular life-preserver, hanging beneath the hawser and provided with a sort of bag, in which a man can sit and be brought ashore without having recourse to the heavier car. Also a similar arrangement in which women and children can be secured.

STATION-HOUSES.

Judging from the sample shown here, the station-houses, which will probably be located upon some part of the coast of New-Jersey for use next fall, are neat and comfortable wooden buildings, having a boat and gun room and living-room on the ground-floor, and keeper's room, store-room, and crew's bedroom above, and well provided with closets, etc. It was designed by and built under the superintendence of Jas. L. Parkinson, architect. Its dimensions are: length, 45 feet 8 inches; width, 22 feet; altogether a very pretty sight to a shipwrecked crew who have just been drawn through the surf. Yet the life of the surf-man, although by no means luxurious, is not without a certain charm that seems attached to every thing connected with the sea; and a portion of this is the noble pride of wrestling with an antagonist of superior strength.

But there are more dangers to the mariner than appertain to the sea or to the weather, one of the most common of which is bad stowage and misplacement of the various portions of a cargo. It is by means of the statistics gathered by the United States Life-Saving Service that such cases as occur repeatedly in one form can be traced to their original cause and the proper remedy discovered. Individual cases will occur; men of but little judgment will always be found to lose vessels; but a long list of any peculiar form of disaster argues a fault that can be remedied or a danger that can be avoided.

For instance, of American steamships sailing to and from the port of New York, take a single class of disasters, that of foundering at sea, actually sinking in deep water from loss of buoyancy, not fire nor collision with other vessels or ice, and it is believed that every such case will be found to have happened upon the passage out from New-York; while in nearly every such case other steamers, often of the same lines, and also sailing-vessels, have ridden out the same gale in the immediate vicinity of the ones lost. Run over the list from the San Francisco lost in the winter of 1853–4, with her enormous loss of life, to the later San Francisco and Evening Star, and they were all *bound out*, while *all steamers bound in rode out the gales*. Having the same builders and owners, similar crews and equipments, the cause of this must be looked for in the difference in the cargoes, and then it is found that the difference in the materials composing the cargo is less than in the manner of stowing them.

In the distant ports, whether Havana or Aspinwall, Galveston or New-Orleans, the captain, officers, and crew are generally about; the cargo is comparatively uniform, whether cotton or sugar, coffee or hides; the stevedore, accustomed to just such continuously, stows by rule methodically, as experience has proven to be best. But in New-York the port captain takes charge, the crew leave, and the cargo, consisting of every thing that can be obtained in New-York, is rushed aboard pretty much in the order of its arrival at the wharf. A single instance of the manner of stowing practised by the steamboat stevedores of the North will best illustrate the point. The vessel was deep, of the class of "sharp built"—a beautiful model, to any seaman's eye; but on the keelson, amidships, were casks of hams, very heavy; on the skin, in the run, whiskey and refined sugar; forward of the hams, bale goods; on the hams, in the centre of gravity, oats, very light; forward, close up under the deck, at the heel of the bowsprit, nails, butts, and screws, very heavy and unyielding; on deck, gas-pipe and casks and crates of bottles. When off to the southward of Cape Hatteras, in not remarkably heavy weather, that vessel would go down to the depths to that degree that she would take the water three or four feet deep over her whole weather bow, filling her whole main deck, and more than once washed casks of bottles over the lee rail, then, staggering with the lee lurch, scooped them up as one would with a bucket. Had she had engines and boilers aboard and driving her into it, she would have been in great peril, if not altogether lost. Yet in the worst of it a small schooner was seen hove-to near by, her decks apparently dry, no spray seen above her rail. But the cargo described was not bad in its material; not like Peruvian guano, granite, or pig-iron; its whole fault was in its location relative to the vessel's centre of gravity and flotation.

A. V.

SILVER.

From the Comanche Mine, Mono County, California, a mass of ore, composed of silver and copper, weighing about 200 pounds, is shown. This ore assays about $300 per ton of silver; it is not worked for copper. An argentiferous galena, which is worked for silver, is shown from Shasta County. An antimonial silver ore from the Rye Patch Mine, Nevada, is said to assay $400 to the ton. From the Belcher Mine, on the Comstock lode, the "great bonanza," are specimens of ore which yield upwards of $1000 a ton. The richest specimen was one of ruby silver from the Reese River district, which assays over $2000 per ton. A specimen of argentiferous sulphate of lead from the Defiance Mine, Inyo County, California, yields 80 ounces of silver per ton.

MERCURY.

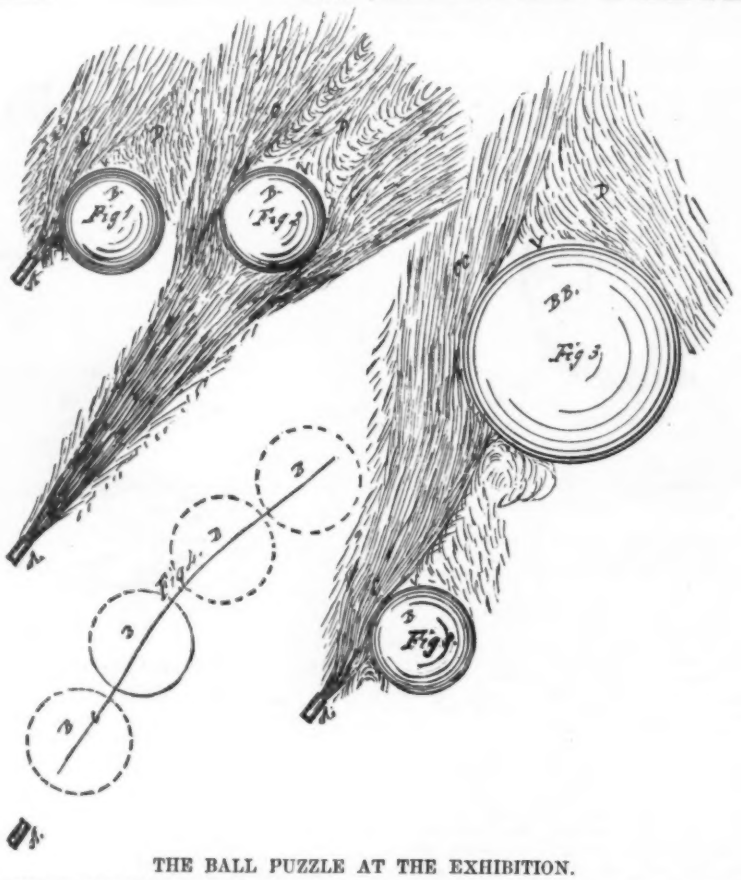
One of the best mines is the Wall-street Mine, in Lake county, California. A large specimen of rock from this mine is shown which is literally dripping with free mercury. The red cinnabar, sulphate of mercury, its usual form, comprises about one third of the rock, and probably one fourth the mercury in the stone is in a free state. The rock yields about 45 per cent of mercury, an exceedingly rich yield. A very large variety of cinnabar ore is shown, all representing productive and valuable mines, and including every kind of quicksilver ore known to the mineralogist

SULPHUR,

pure, or nearly so, is found in many places. A specimen is shown from Pyramid Lake, where it crops out of a hill in a layer several feet in thickness. In Humboldt County, Nevada, which is called "Inferno" on account of the sulphur, is a deposit, some twelve miles long, two or three miles in width, and from four to twelve feet thick, of pure sulphur. It is of a volcanic formation, and has oozed out of a mountain at the foot-hills of which it is found, or possibly is the deposit of hot springs.

COAL.

Bituminous coals are found in large and thick layers in Shasta County, California. The specimens on exhibition are evidenttly of great value. It is said that some of the richest coal deposits in the United States are found in the cretaceous deposits in the Rocky Mountains. One seam has 75 feet in thickness of solid coal, and there are thinner seams above and below it. The mines at Mount Diabolo are chiefly worked to supply the San Francisco market, where the product is sold at about $8 per ton. No anthracite coal has yet been discovered in this region.



THE BALL PUZZLE AT THE EXHIBITION.

EXHIBIT OF THE CENTRAL PACIFIC RAILROAD.

IN Agricultural Hall is an exhibit of the agricultural and mineral resources of the Pacific Slope, made under the auspices of the Central Pacific Railroad. This corporation, by giving free transportation to the exhibits and taking charge of and arranging them on their arrival here, have succeeded in collecting and arranging a superb display of the products of that wonderful country, whose resources of all kinds are unsurpassed by any section. The territory from which the collection was made is not bounded by any State lines, but is that country tributary to the great trunk line which makes the exhibit. Thus, Nevada, Utah, Oregon, and even Mexico are drawn upon for specimens as well as California; and China and Japan would have been represented had not those nations made a full exhibition of their characteristic products.

THE CENTRAL PACIFIC RAILROAD COMPANY

of California was one of the companies authorized by act of Congress to construct a railroad from the Missouri River to the Pacific Ocean. It was empowered to construct its road eastward from the Sacramento River until it should meet and connect with the Union Pacific Railroad, which it did on the 10th of May, 1869, near Salt Lake City. This road was consolidated with the California and Oregon Railroad Company, which runs south from Portland, Oregon, and the Western Pacific Railroad Company, and the consolidated company was called the "Central Pacific Railroad." The completion of these railroads was considered of so great national importance that the United States Congress gave to each of the companies an extensive grant of alternate sections of land on each side of their tracts. About 3,000,000 acres of land thus became the property of the Central Pacific Railroad; and to dispose of this vast domain and people it with settlers is not only for their immediate interest and that of the country, but upon the development of the country's boundless resources must the future prosperity of the corporation depend. The entire length of the road, including 570 miles of steamer lines, is 2097 miles.

MINERAL EXHIBITS.

The collection of gold ores and free gold from the most celebrated mines and mining regions of California is a very rich and instructive one. Each specimen is plainly labelled with the name of the mine from which it was taken.

THE BALL-SUSPENSION PUZZLE AT THE CENTENNIAL.

AMONG the exhibits made in Machinery Hall at the Centennial Exhibition by the Westinghouse automatic brake is the curious performance of a ball suspended by a current of compressed air issuing from a nozzle standing at an angle of about sixty degrees. In Fig. 1 in our illustration, A represents the nozzle from which the compressed air issues; B represents the ball. There are three sizes of balls used in the demonstration: first, a glass ball, which, placed in the position shown in Fig. 1, will revolve very rapidly from the left hand towards the right, the axis of its motion remaining in about the same part of the ball; placed a little farther off from the nozzle A, this ball will revolve less rapidly, while the axis of its motion will change continuously with almost lightning speed; but if placed at a certain position a distance from the nozzle, the ball will simply stand in the current of air, and maintain a steady position without either revolving or falling. If this ball is placed in the position shown in Fig. 2, and given motion after it is supported in the jet of air, it will vibrate along the jet either in an almost straight line or with a motion whose line of travel is denoted by the line *c* in Fig. 4, in which figure A represents the nozzle, and B B B B the ball in various positions on the line of motion *c*. It is noteworthy that the ball may be touched lightly by the fingers when in any position,

the result being merely to give it a slight swinging motion. The revolutions of the ball when in the position shown in Fig. 1 are about 1500, and when in that shown in Fig. 2 about 1000, revolutions per minute. In addition to this there is a pine-wood solid ball, about 2¼ inches in diameter, which will operate in precisely the same manner as the glass ball. Another pine-wood solid ball, about 4 inches in diameter, will operate in like manner, and then a hollow rubber toy-ball, about 6 inches in diameter, is placed in the air-current, its action being similar to the above, except that the centrifugal motion of the ball causes it from its elasticity to flatten about the centres of the axis of its movement, while the diameter increases in proportion. Each of these balls is marked with colored stripes to show the nature and direction of its rotatory motions. In the case of the rubber ball, the line of the axis of its rotatory movement does not remain constant, but traverses horizontally, so that the plane of its movement is at times in a line with the direction of the air-blast, while it is at others at a right angle to said blast, the axis of movement rotating horizontally with a slow motion, regular and continuous, in one direction. When this ball, however, is at a certain distance from the nozzle, it will cease to rotate; while if placed in the position show in Fig. 1, its action is to simply rapidly revolve, with but a slight variation in the axis of its movement.

The final exhibition is to place a glass ball close to the nozzle *A*, and to, at the same time, place a little farther off the large rubber ball, their relative positions being shown in Fig. 3. In these positions the two balls simply revolve in a stationary position. The questions to be solved are: Why does not the air-blast blow the balls away? What causes the rotation? What causes the changes in the axis of the movements? What supports the ball in the air? and why are all the balls stationary when placed at a certain distance from the nozzle?

THE GREAT EXHIBITION.

A TOUR THROUGH THE BOILER-HOUSES—THE MOTIVE POWER FOR MACHINERY HALL AND OTHER BUILDINGS.

THERE are several large boiler houses attached to the principal buildings on the Centennial Exhibition grounds, each containing boilers of different construction. They comprise altogether a very complete exhibition of the various methods of making steam for power purposes, with relative safety, economy and dispatch, and may be studied while at work. In describing them, particular attention is directed to those which are new to the public as of foreign make or of recent invention, such well-known boilers as the Harrison, Corliss, Rogers, and others being so well known as to require scarcely any description. There are many patent attachments applied to the boilers, some of which are also described more for the purpose of directing the attention of engineers to new contrivances, than to make a complete list of those exhibited. As to the merits of particular boilers and attachments, no opinion is expressed, and the statements of evaporating power, consumption of fuel, etc., are those made by the makers or patentees. It is expected that during next month there will be a competitive trial of the boilers, when their several powers will be tested under known conditions.

BOILER HOUSE NO. 1.

The most easterly boiler house south of Machinery Hall is one of the most interesting studies to Americans of all the boiler houses, as it contains three "Galloway" boilers from Manchester, England, and other apparatus from English makers. They supply steam to the engines in the British Department of Machinery Hall.

The Galloway Boiler.—This form of boiler has been in use in England for upwards of twenty-five years, and the three exhibited have been "contributed by the makers (W. & J. Galloway & Sons, Manchester) at the request of the British Royal Executive Commissioners, to enable them to exhibit the best type and form of steam boiler now in use in Great Britain." The three boilers exhibited are each 28 feet long by 7 feet diameter, and are made for an ordinary working pressure of 75 pounds to the square inch. The shell or casing is of Bessemer steel plates, three eighths of an inch thick. The two furnaces attached to each boiler are also made of steel plates in three rings, flanged and riveted together so as to prevent any seam or rivet-head from being exposed to the action of the fire. Inside of the cylindrical shell there is an irregular oval flue (the latest improvement here exhibited has the bottom of the flue arched) and in the flue are placed thirty-three conical water-tubes, 10½ inches in diameter at the top or large end, and 5½ inches in diameter at the lower end. These serve also as stays, and, like the flue itself, are made of wrought-iron. The tubes are welded and flanged from one piece of iron. Along the sides of the flue are wrought-iron stops or bafflers, which increase the heating surface and deflect the currents of heated air, causing them to impinge against the vertical tubes. The conical form of the tubes gives a better opportunity for the steam to ascend, and secures a more direct action from the ascending currents of heated air than could be obtained from cylindrical upright tubes, or conical tubes with the smaller end at the top, and their form also admits of their ready removal from the top for repairs. It is claimed that there is a complete circulation of the water effected in the "Galloway," the highly heated flues drawing the water up and allowing it to fall, over the sides of the flue, to the bottom. The heated air passes through the flue containing the Galloway tubes, which are so placed as to obstruct its passage, thence along both sides of the boiler to the front, and finally under the boiler to the chimney. The heating surface of each of the three boilers exhibited is 900 square feet. Two only are used at a time, and each is capable of driving a condensing engine of 250 or 300 horse-power. The noticeable attachments are alarm whistles for high pressure and low water, fusible plugs in the crown of the furnace, and a dead weight safety-valve, which it would of course be more difficult for an engineer to tamper with than a lever safety-valve, where weights are multiplied by the leverage given them. The construction of the Galloway boiler may be studied from a model exhibited in the British Department of Machinery Hall. Of its evaporating powers and economy, the exhibitors show, from a trial made of a boiler two feet shorter than that exhibited, and of about 150 square feet less heating surface, that 10.82 pounds of water, at an average temperature of 61.75 degrees, were evaporated per pound of coal used in a trial lasting ten hours. This is equivalent to the evaporation of nearly thirteen pounds of water at 212° per pound of coal. The steam reserve of the Galloway is noticeably large when compared with that of most American boilers.

Green's Fuel Economizer.—Attached to the boiler, chiefly for the purpose of exhibiting its uses, is Green's Fuel Economizer, exhibited by Edward Green & Son, of Manchester, England. This apparatus is in use in several large manufactories in this country, including a few in Philadelphia and vicinity. It is made of a series of tubes with turned and bored socket-joints, through which the feed water circulates before entering the boiler to which the economizer is attached. The waste gases and smoke from the furnace pass around the pipes of the economizer on their way to the chimney, and heat the feed water contained in them to a temperature of from 200 to 300 degrees. The important and essential feature of this apparatus is the scraper which incloses each tube and passes slowly up and down, keeping the tube free from soot and incrustations of all kinds, so that it always presents a clean heating surface to the heated air and smoke.

Pearn's Pump.—A patent double-acting steam-pump, with one ram, exhibited by Frank Pearn & Co., Manchester, is also attached to the Galloway boilers. The characteristic of the pump is in the method of packing the ram. The barrel of the pump is cast in two separate parts, the lower barrel in connection with a part of the framing, and the upper barrel independently. The lower barrel is enlarged at the top, so that when the top barrel is fixed in position around the ram, a hollow ring is still left between a portion of the outer surface of the top barrel and the inner surface of the bottom barrel. This hollow space serves for the packing, which is pushed down. To make it water-tight, a gland or stuffing-box cover is fitted loosely around the outside surface of the upper barrel, and by means of four screw-bolts, is screwed down to the top surface of the bottom barrel. The upper barrel is kept in position by being firmly screwed to the two columns. As the gland or stuffing-box does not touch the plunger, no injury can be done if the bolts are not evenly screwed down, and there is little, if any, opportunity for putting transverse strains on the ram. The exhibited pump has a ram of 5-inch diameter and 8-inch cylinder. The length of the stroke is six inches; number of strokes per minute, 60; and rated capacity 2965 gallons per hour.

BOILER HOUSE NO. 2,

which is east of the pump annex to Machinery Hall, contains twenty Corliss boilers, which supply steam to the great Corliss engine, which drives the machinery in the Machinery Hall, and they also supply steam to the pumps in the hydraulic annex.

The Corliss Boilers exhibited are upright tubular boilers, each with a cylindrical shell four feet in diameter and twelve feet in length. Each boiler contains 48 3-inch tubes. The boilers are rated at 70 horse-power, and the whole number, 20, would furnish the nominal horse-power of the great Corliss engine 1400, but only eight are used for supplying the engine with steam and eight for supplying steam to the hydraulic annex. The other four are held in reserve.

BOILER HOUSE NO. 3

is also south of Machinery Hall, but west of the hydraulic annex. It contains a number of boilers of different patterns. Nearly all of the American boilers exhibited are sectional, and are so nearly like each other in principle that only the peculiarities of each are noted.

The Exeter Boiler.—The Exeter, N. H., Machine Works exhibits an Exeter sectional boiler, rated as of 50 horse-power. It consists of a series of sections, each of which is a boiler in itself, rectangular in form, 3½ feet long, 3 feet high, and 4 inches wide. Each section is cast with twelve openings through it 2 inches by 12 inches, so that the section is, practically, a series of connected boxes, with twenty-nine square feet of heating surface. In setting the boiler the upper half of the section is shut off from the lower half by brick work and square bars of iron, so that the heated air from the furnace is compelled to pass between and along the sides of the lower half of the sections to the rear of the boiler, then up and back through the openings in the upper half of the chimney in the front. Among the advantages claimed for this boiler are the safety of all sectional boilers; the ease with which the several sections may be cleaned, the fact that no joints are exposed to the direct action of the fire (all steam and water connections are made outside the brick work), and that any section may be readily disconnected and removed from the top of the boiler without disturbing the brick work on the other sections.

W. E. Kelly's Sectional Safety Boiler, exhibited by W. E. Kelly, New-Brunswick, New-Jersey, is also rated at 50 horse-power. The front chamber of each section is vertical, and the tubes are inclined over the fire at an angle of about one to eight. In each tube there is a partition with diaphragm, and the water line of the boiler is above all of the water tubes, but below a horizontal tube for the superheating of the steam. Each tube is independent of the others, and is closed at the rear end, and each can expand or contract independently of the others. The theory of the circulation of the water is that the lower part of the tube will be the most highly heated and will generate the most steam, which, being intercepted by the partition plate and prevented from rising to the upper part of the tube, will pass along the lower side of the partition to the front chamber, and thence to the dome. The water will flow down the coolest part of the tube (the upper half) and thence through an opening into the lower half, where its circulation will be accelerated by the volume of steam seeking an exit to the front chamber. From this front chamber the steam passes into the lower part of a horizontal tube, also divided by a horizontal partition, and thence into the upper part, whence it passes to the steam drum. The boiler is so constructed as to admit of repairs either to a pipe or a section without disturbing other parts, and it is supplied with a water reservoir (which may be put where the heated gases on their way to the chimney will pass around it), from which the engineer may draw feed water at his pleasure.

Lowe's Tubular Boiler, exhibited by Lowe & Watson, Bridgeport, Connecticut, is of an entirely different kind from those just described. It has a cylindrical shell and horizontal tubes like those of a locomotive boiler, through which the heated air and gases pass. Thence the hot air is carried around and under the boiler to the front.

Smith's Steam Boiler Furnace.—Charles D. Smith, Philadelphia, exhibits his improved steam boiler furnace, or setting for boilers of any kind under an ordinary cylindrical boiler, rated at 100 horse-power. The supports for the boiler, instead of being made of firebrick, are made of iron columns or heaters filled with the feed water, so that the water gets the benefit of heat ordinarily wasted. The bridge wall is also hollow, and is kept full of water, and there are pipes run in the pit from the bridge wall to the rear of the boiler to absorb and utilize the waste heat there. In short, the setting is made of reservoirs of water, connected with the boiler, and the heat, which brick walls simply absorb, is utilized.

The Howard Sectional Safety Boiler, built by the National Tube Works Company, McKeesport, Pa., is rated at 50 horse-power. The tubes are inclined from front to rear, and are made of wrought iron. There are 30 9-inch tubes. The steam drum is also of wrought iron, and is about fourteen inches in diameter.

Root's Sectional Safety Boiler is exhibited by Abenderoth & Root Manufacturing Company, New-York. This is very similar in general form to other sectional boilers in which tubes are used, and is made of wrought iron. Its principal novelty is the simplicity of the method of connecting the tubes together. The uniformity in the size and shape of its parts is an advantage, as it can be enlarged or reduced in size and capacity at small expense. Its form of construction is also such as to admit of its being cleaned or repaired with ease. Attached to the boiler is Root's automatic feed regulator, which regulates the supply of water to the boiler by admitting steam from the boiler into the regulator when the water falls below a certain level. The pressure of the steam acting upon a diaphragm raises a lever which opens a valve admitting water or starting the pump. When the pressure in the pipes on the diaphragm is equalized, a weight on the other end of the lever causes it to fall, stopping the supply.

The Babcock & Wilcox Tubulous Boiler, exhibited by Babcock & Wilcox, New-York, is also a sectional boiler, and the tubes of wrought iron are placed in an inclined position. They are connected with each other, and with a horizontal steam and water drum, by vertical passages at each end, and with a mud drum at the lower end. The tubes are "staggered," or one row placed over the spaces of the previous row. The end connections are each cast in one piece of steel, and are connected with the steam and mud drums by short tubes expanded into bored holes, doing away with all bolt connections. The fire is made under the front or higher end of the tubes, and the products of combustion pass up and down and up again through the spaces between the tubes before entering the chimney. The boiler is suspended entirely independent of the brick work or fire front. In the exhibited boiler there are 98 tubes, each three and a half inches in diameter. The advantages claimed for the boiler are chiefly in form and construction, as it does not differ in principle from other sectional boilers where tubes are used.

A feed-water boiler, supplied with exhaust steam from an engine in the machine shop, supplies the boilers in No. 3 Boiler House with hot feed water. The boilers in this house furnish steam to engines and pumps in the hydraulic annex to Machinery Hall.

BOILER HOUSE NO. 4

is also situated south of Machinery Hall, near the western end of the building. It contains some well-known Philadelphia boilers.

The Harrison Boiler is probably the best known of these. At the time of its invention it was altogether novel in form and general principle, and was slowly introduced until 1864, five years after the first Harrison boiler was erected, when the manufacture was begun on a large scale. It is a sectional boiler made of cast-iron spheres cast in bricks of two and four, and connected by curved necks, with rebate machine-made joints, held together by wrought iron bolt with caps at the end. The joints serve as safety-valves under undue pressure. The honeycombs of balls are disposed in the furnace much as the tubes of a sectional tubulous boiler, being inclined over the grate. The advantages claimed for it are perfect safety, freedom from corrosion, quickness in getting up steam, the fact that it produces superheated steam without extra apparatus, and the ease with which it can be enlarged or replaced in any of its parts, which are all multiplications of a single form. Attached to the Harrison boiler is an exhibit of the Ryder reciprocal grate, also shown in Boiler House No. 3. In this grate there are two sets of bars, one of which is stationary, and the other has a rectilinear and vertical reciprocating motion. The lever for moving the bars, which work on friction rollers, is easily operated. Each bar is toothed, and the grate is slightly higher in the middle than at the sides.

Andrews' Superheating Tubular Boilers.—In this boiler, exhibited by Wm. D Andrews & Bro., New-York, the fireplace occupies the entire horizontal area except the narrow water spaces or legs, which entirely surround it, and it has unusual height, space and extent of heating and grate surface. The heated air passes from the furnace through short tubes to a combustion chamber in the back, thence through tubes in the boiler to the front chamber or breeching, and thence through tubes in the steam space to the upper part of the back breeching, to which is attached the smoke pipe. A feature of the boiler is the means taken for the thorough combustion of the fuel by the admission of air through the door and into the combustion chamber. The air admitted to the latter place is heated by contact with an iron plate therein before it is admitted through graduated openings to the chamber, where it meets and mingles with the ignited gases from the fire-place. The boiler exhibited is rated at sixty-horse power.

Rogers & Black Boiler.—Charles D. Miller exhibits a Rogers & Black boiler, rated at 30 horse-power, which is a cylindrical boiler, with tubes outside for heating and circulation.

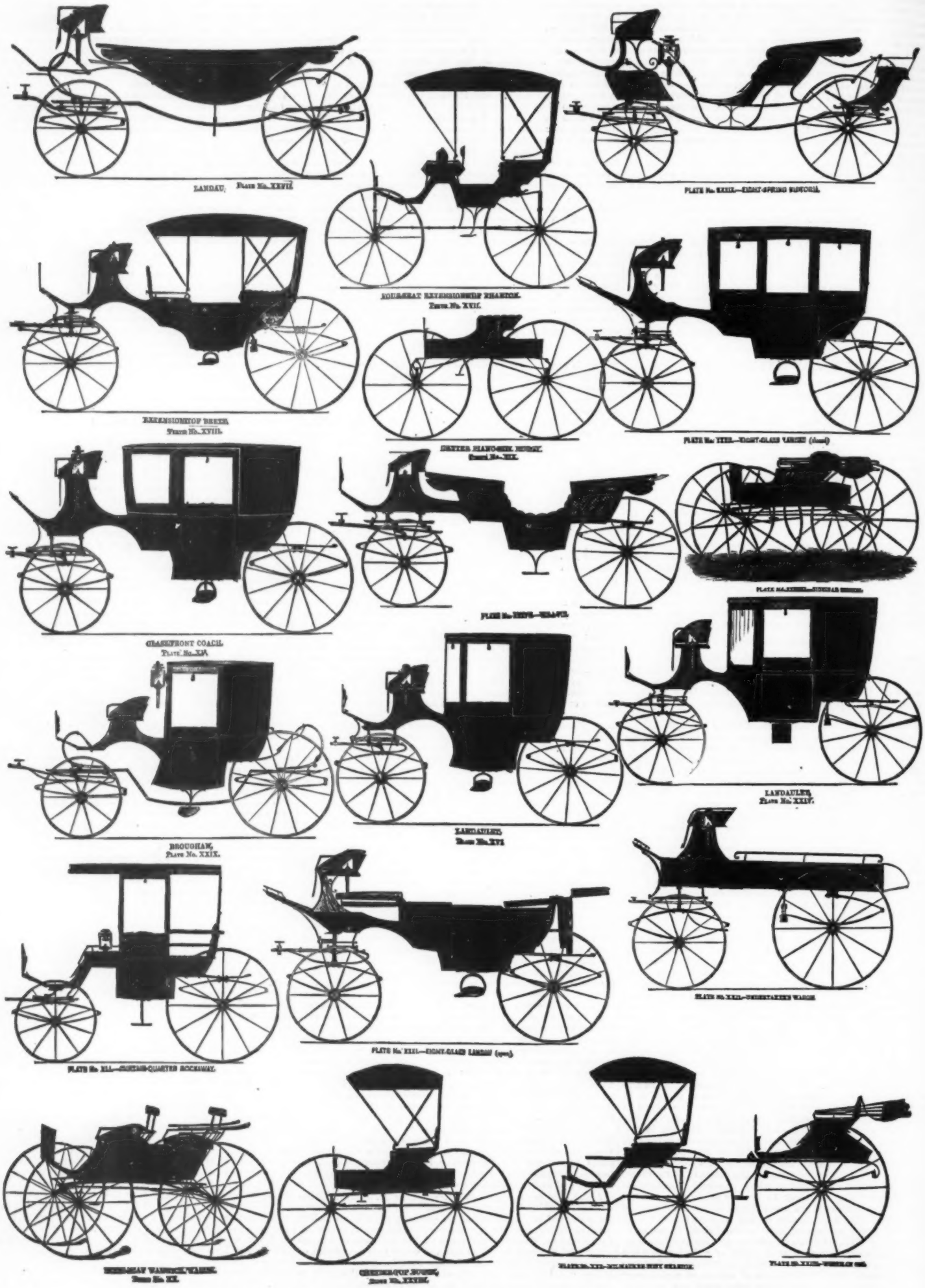
Lynde's Sectional Safety Boiler is another boiler in which the steam is generated in tubes. It differs from others in many ways, chiefly in having the tubes return over the fire seven times, and in having an unusually large steam drum or reservoir. It is provided with the Eclipse injector, and with several patent appliances of the same inventor, as the Acme governor, the Acme stop valve, Lynde's low-water alarm, and the Acme damper regulator.

The Wiegand Boiler, the invention of Lloyd Wiegand, of this city, is a well-known sectional boiler, with double tubes. The one on exhibition is rated at 100 horse-power, and is of an improved construction, the tubes and connections having been greatly enlarged over the sizes in the old model.

Firmenich's Wrought-Iron Tubular Boiler, exhibited by J. & G. Firmenich, Buffalo, N. Y., is an upright tubular boiler, and thus differs essentially from most of those that have been examined. The base, as it were, is two large mud drums, one on either side, but two feet below the fire grate. From these rise obliquely over the fire, stacks of wrought-iron boiler tubes. They end in two water and steam drums, which are connected with a steam drum in the centre, forming the crown of this pyramidal structure. The whole is encased in brick work. There is a fire-bridge wall in the furnace, dividing it into two compartments, and compelling the products of combustion to pass over it and down to the lower part of the back of the furnace, whence they enter the chimney. It is claimed that there is perfect circulation of the water, and there is certainly little opportunity for scale to form, nor for the heating tubes to become incrusted with dirt.

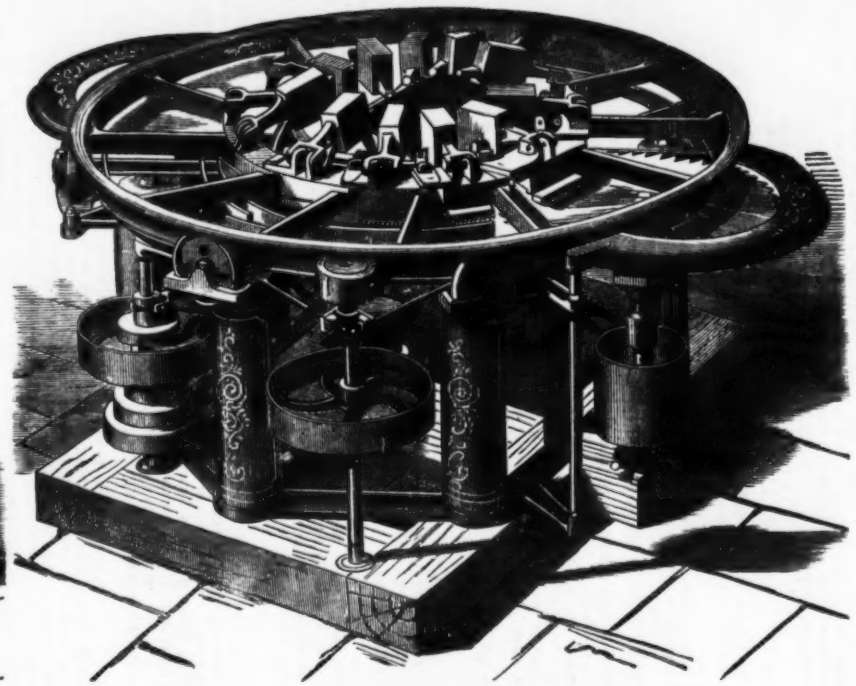
Miscellaneous.—In this boiler house will be found several exhibits of another kind. Shapley & Wells, Binghamton, N. Y., exhibit a hoisting engine. Wm. D. Andrews and Williamson Bros., of this city, also exhibit hoisting engines in operation. The Williamson engine is a single engine, with a double drum. The Andrews engine has two drums,

(*Continued on page 580.*)

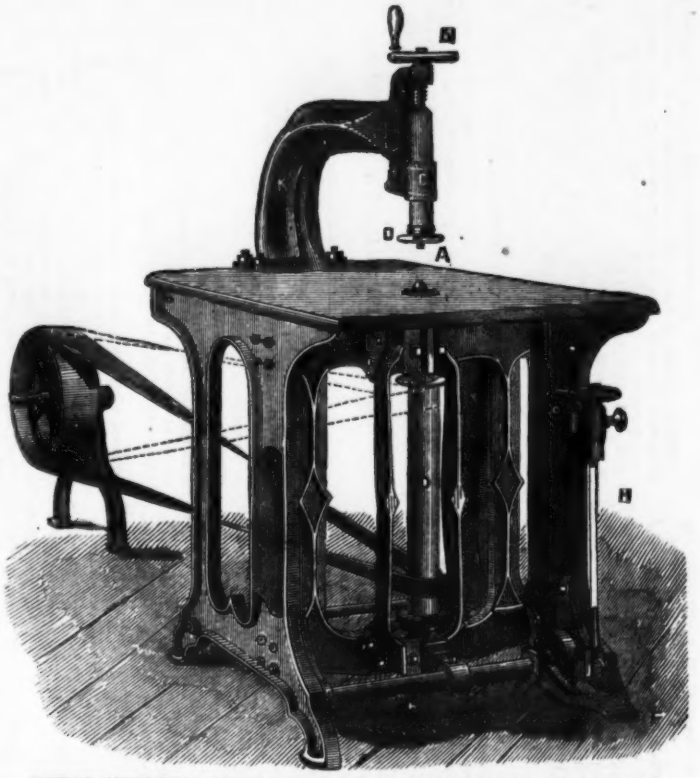


THE INTERNATIONAL EXHIBITION OF 1876.—THE CARRIAGE EXHIBIT.

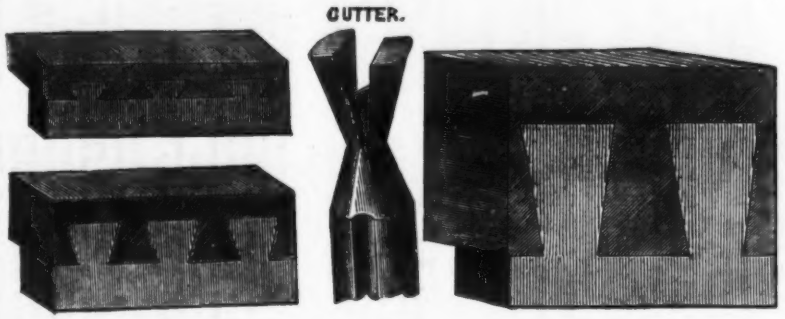
MACHINE FOR DRESSING HEADS OF ALL SIZES.



BURT'S SHINGLE MACHINE.



DOULT'S MOULDING MACHINE AS USED FOR SURFACE MOULDING AND PANELING.



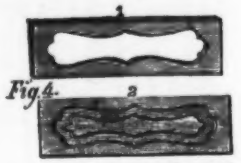
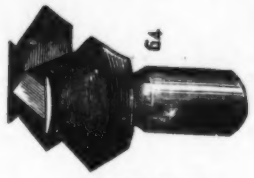


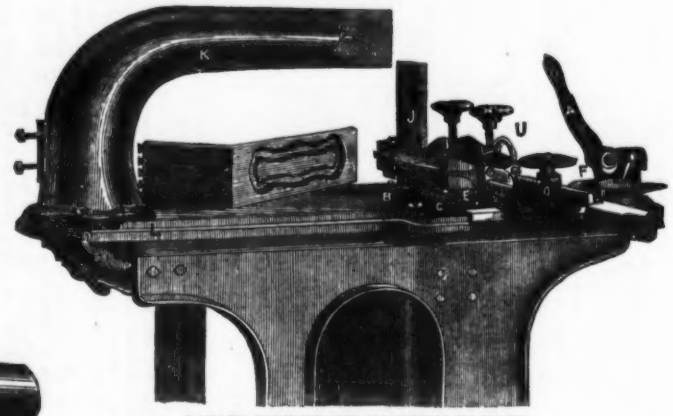
FIG.1.-PATTERN FOR CUTTING PANEL.

CHUCK.

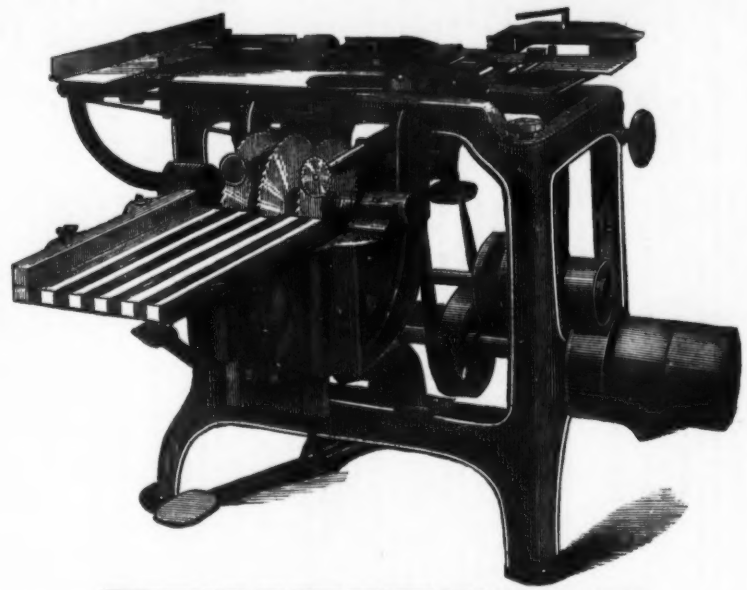
DETAILS OF MOULDING MACHINE.



SURFACE CUTTER.



BOULT'S CARVING AND MOULDING MACHINE.



GREENLEES DOOR AND BLIND RELISHING AND MORTISING MACHINE.

THE INTERNATIONAL EXHIBITION OF 1876.—WOOD-WORKING MACHINES.

(Continued from page 577.)

entirely disconnected, which can be used alternately or together. A Baxter hoisting engine and a Rider compression engine, worked with hot air, are also exhibited, but not in operation; also the Eureka safety power engine, with sectional cast-iron boiler, exhibited by B. W. Payne & Sons, Corning, N. Y.

BOILER HOUSE NO. 5

is situated south of the steam saw mill, and west of Machinery Hall, and supplies steam to the engines driving the saws.

The Pierce Rotary Tubular Boiler is here, and, as it is the only one of the kind exhibited in the boiler houses, it attracts considerable attention. This boiler is six feet long, four feet in diameter, and has 18 four-inch and 18 three and a half inch tubes, 278 square feet of heating surface and 20 square feet of grate surface. Notwithstanding its comparatively small size, it is rated as of 60 horse-power. It is a cylindrical, rotary, tubular steam boiler, with two circular rows of tubes running from end to end. The outer row of tubes are nearly surrounded by buckets or elevators, which are so constructed as to partially encircle them and keep the tubes submerged in water, and also drench the inner surface of the boiler shell above the water line with water at each revolution. The inner row of tubes act as super-heaters for drying as well as generating steam. The boiler is encased in brick-work and supported by trunnions, resting upon friction rollers, set in the brick-work, and is rotated about one revolution per minute by the steam pump which supplies the boiler with water.

Water is supplied in an unchangeable amount by an automatic feed-water regulator, and enters the boiler through one trunnion while steam is withdrawn through the opposite trunnion. The flame and heated gases arising from the grate completely surround the boiler; thence pass through the *outer* row of tubes to the opposite end, emerging into a chamber, thence returning through the *inner* row of tubes *en route* to the stack or chimney. The mechanism of the boiler is comparatively simple, but can not be described without diagrams. It is claimed for this boiler, that in a test made by Prof. R. H. Thurston, of the Stevens Institute of Tecnology, it evaporated ten and one quarter pounds of water from a temperature of 212 degrees Fahrenheit, into dry steam, by the consumption of one pound of fuel; that it evaporated a cubic foot of water per hour with but eight feet of heating surface, and that in three minutes after starting a fire with wood, steam began to form, and the pressure in twenty minutes rose to sixty-five pounds. The constant agitation of the water will, it is claimed, prevent incrustation, and as the boiler is suspended free from masonry, it will not become corroded.

The Anderson Sectional Water Tubular Boiler is in the same boiler house, and is exhibited by P. P. Mast & Co., Springfield, Ohio. There are two of these boilers, each of 112 horse-power, but only one is used at a time. Each section of this boiler is composed of two front manifolds, and a rear one connected by horizontal sets of tubes. The sections are united to each other by nipples, and the sets of sections to a central column, to the top of which is attached the steam dome. There is an automatic water regulator attached. The products of combustion are made to pass along the lower set of tubes and back to the front along the upper set of each section. The boiler is particularly designed for use with waters which require purification, as the waters of the Western rivers, and the mud drum is a conspicuous part of the apparatus. The water is heated, thus securing a complete separation of the impurities held in solution, and is then allowed to settle in the mud drum before being passed into the boilers. The boilers which supply power to the engine in Agricultural Hall are of the same size and pattern, and are in the boiler house east of Agricultural Hall.

BOILER HOUSH NO. 6

is situated between Machinery Hall and the Shoe and Leather Building, and supplies power to the high-pressure engine in the latter building. There is a common tubular boiler attached to J. B. Hoyt's furnace for the combustion of bituminous coal and the prevention of smoke. The coal is fed into the furnace from the sides, and air for the combustion of the gases through the furnace door, and through small openings between the bricks in the upper corner of the furnace. The air thus entering is highly heated by circulation between hollow arches over the furnace before it enters the furnace, and so carries back some of the heat which would otherwise be wasted, and prevents the chilling of the gas. The latter is generated under the hot coke, and, after leaving the coal at a white heat, unites with the air and burns. The products of combustion then pass through the flues of the boiler. The coal is kept piled up on shelves, in convenient position for being fed into the fire in small quantities. The grate surface is 15 square feet, the heating surface of boiler 700 square feet, cross-section of chimney 5 feet. The furnace is suited to burn 3000 pounds of bituminous coal in a day of twelve hours, and the boiler will furnish 2500 pounds of steam per hour, being equivalent to forty horse-power in an ordinary high-pressure steam engine.

The Armstrong Heater, Filter, and Lime Catcher is exhibited in this boiler house, the high-pressure engine in the Shoe and Leather Building exhausting into it. The feed water is heated by it to about 200 degrees, besides being filtered. The heater, filter, and lime catcher is exhibited by Bronson, Matheis & Co., Toledo, Ohio, and is simply an arrangement of drip pans, filters, etc., in a chamber filled with the exhaust steam, through which the water has to pass before being fed to the boiler.—*Public Ledger.*

CARRIAGE EXHIBITS—ILLUSTRATED.

ON page 515 of our SUPPLEMENT we gave some illustrations of carriage exhibits, and we herewith present another series, nineteen in number, for which we are indebted to the *Carriage Monthly.*

Plate XV.—Glass-Front Coach. Exhibited by Messrs. Wm. D Rogers & Co., New-York.

Dimensions.—Width of body, at hinge-pillar, 52 in.; at lock-pillar, 49½ in.; back at arm-rail, 43½ in.; front at arm-rail, 39 in. Boot, 34 in. Turn-under, 4 in. Wheels, 3 ft. 2 in., and 4 ft. Hubs, 6 by 9 in. Spokes, 1⅝ in. Tire, 1⅜ by $\frac{7}{16}$ in. Axles, 1½ in. (Collinge). Springs, 1¼ in. steel, 5 plates, 40 in. long. Front spring, 8½ in. open; back spring, 7½ in. open; Fifth-wheels, 21 in. diameter. Kingbolt, 6 in. forward.

Mountings.—Inside mountings of body in ebony, rosewood, and gold. Gold moulding around body as before explained; also around dickey-seat; axle-nuts, gold.

Plate XVI.—Landaulet. Exhibited by Messrs. Wm. D. Rogers & Co., New-York.

Dimensions.—Width of body at hinge-pillar, 50 in.; at lock-pillar, 46½ in.; back at arm-rail, 43½ in. Width of boot at lock-pillar, 40½ in.; at heel of bracket, 31 in. Turn-under, 4½ in. The back of the body is swelled 1 in. The door has the convex-concave sweep, the concave commencing at the bottom of quarter-panel. Wheels, 3 ft. 2 in., and 3 ft. 10 in. Hubs, 5½ by 7 in. Spokes, 1⅝ in. Tire, 1½ by $\frac{7}{16}$ in. Axles, 1$\frac{7}{16}$ in. (Collinge). Springs, 1¼ in. steel, 4 plates, 38 in. long. Fifth-wheels, 15 in. diameter. Track, front, 4 ft.; back. 4 ft. 10 in.

Plate XVII.—Four-Seat Extension-Top Phaeton. Exhibited by Messrs. D. M. Lane & Son, New-York.

Dimensions.—Width of body over all, on top, 32 in. Turn-under, 1½ in. Wheels, 3 ft. 6 in., and 4 ft. Hubs, 4 ft. by 7 in. Spokes, 1 in. Tire, ¾ in. Axles, 1$\frac{7}{16}$ in. Springs, 3 ft. 2 in.

Plate XVIII.—Extension-Top Brett. Exhibited by Messrs. D. M. Lane & Son, New-York.

Dimensions.—Width of body at hinge-pillar, 50 in.; at lock-pillar, 48 in.; back arm-rail, 42 in. Turn-under, 3½ in. Wheels, 3 ft. 6 in., and 4 ft. Hubs, 5 by 8 in. Spokes, 1⅝ in. Tire, 1½ in. Axles, 1½ in. Springs, 1½ in. steel, 5 plates, 38 in. long. Fifth-wheels, half circle, 26 in. diameter. Track, 5 ft. 2 in.

Plate XIX.—Dexter Piano-Box Buggy. Exhibited by Messrs. D. M. Lane & Son, New-York.

Dimensions.—Width of body, 20 in.; length of body, 50 in. Seat-frame extends ⅜ in. each side. Side flare of body, ½ in. Wheels, 3 ft 10 in., and 4 ft. 2 in. Hubs, 3½ by 6 in. Spokes, ⅝ in., light. Tire, ¼ in. Axles, ⅜ in. Springs, 1½ in. steel, 4 plates.

Plate XX.—Four-Seat Warwick Wagon. Exhibited by R. M. Stivers, New-York.

Dimensions.—Width of body on top, outside, 28 in.; on bottom, outside, 26½ in. Seat-frame extends 1½ in. each side. Wheels, 3 ft. 9 in., and 4 ft. Hubs, 3½ by 6½ in. Spokes, 1½ in. Axles, 1 in. steel. Tire, ¾ in. Springs, circular, 1½ in. steel, 3 plates; end half springs, 1½ in. steel, 5 plates, 29 in. long from centre of side-bar. Side-bars, 2 in. deep in centre, 1½ in. deep on end.

Plate XXI.—Milwaukee Pony Phaeton. Exhibited by L. Coad, Milwaukee, Wis.

Dimensions.—Width of body on seat-rail, 34 in.; on top of seat, outside, 43 in. Rockers framed up square. Wheels, 3 ft. 3 in., and 3 ft. 9 in. Hubs, 3½ by 6½ in. Spokes, ⅞ in. Tire, ¾ in. Axles, ⅞ in. Springs, 1¼ in. steel, 3 plates front, 4 plates back. Perch, ⅞ in. square. Fifth-wheels, ⅜ in., 12 in. diameter.

Plate XXII.—Undertaker's Wagon.

Dimensions.—Width of body, 40 in. inside of panels. Panels, ⅜ in. thick. Wheels, 3 ft. 4 in., and 4 ft. 3 in. Hubs, 5 by 7 in. Spokes, 1½ in. Tire, 1½ in. Axles, 1½ in. Springs, 1½-inch steel, 4 plates.

Plate XXIII.—Whitman Gig.

Dimensions.—Width of body on top, 22 in. Seat projects ⅜ in. each side. Wheels, 4 ft. 8 in. Hub, 3½ by 6½ in. Spokes, 1 in. Axle, 1 in. Tire, ¾ in. Springs, 1½-in. steel, 3 plates.

Plate XXIV.—Landaulet (three-quarter size). Exhibited by J. Beckhaus.

Dimensions.—Width of body at hinge-pillar, 51 in.; at lock-pillar, 46½ in.; back at arm-rail, 43½ in.; front, 34 in. Boot, 32 in. Turn-under, 4 in. Wheels, 3 ft. 2 in., and 3 ft. 10 in. Hubs, 5½ by 7½ in. Spokes, 1½ in. Tire, 1⅜ by ⅝ inch. Axles, 1½ in., Collinge pattern. Springs, 1½-in. steel, 5 plates, 37 in. long. Fifth-wheels, 26 in. diameter.

Plate XXVII.—Landau. Exhibited by Messrs. Million, Guiet & Co., Paris, France.

Dimensions.—Width of body at hinge-pillar, 50 in.; back, 42 in. Boot, 32 in. Wheels, 3 ft. 6 in., and 4 ft. Hubs, 6 by 8½ in. Spokes, 1⅜ in. Tire, 1½ by ½ in. Springs, lower half, 2-in. steel, 37 in. long, 4 plates front, 5 plates back. C-springs, 6 plates, 1½-in. steel Axles, 1½ in., Collinge pattern.

Plate XXVIII.—Chester Top Buggy. Exhibited by Messrs. J. Goold & Co., Albany, N. Y.

Dimensions.—Width of body on top, 27 in. Side-flare, ½ in. Seat-frame projects 1½ in. each side. Wheels, 3 ft. 10 in., and 4 ft. Hubs, 3½ by 6½ in. Spokes, 1 in. Springs, 1¼-in. steel, 3 plates back, 2 plates front, 21 in. long from centre to centre of bars. Side-bars, 2 by 1½ in. in centre, and 1 in. square at ends.

Plate XXIX.—Brougham, on Eight Springs. Exhibited by Binder Bros., France.

Dimensions.—Width of body at hinge-pillar, 50 in.; back, at arm-rail, 42 in.; front, at lock-pillar, 42 in. Boot, 32 in. Wheels, 2 ft. 11 in., and 3 ft. 9 in. Hubs, 6 by 8½ in. Spokes, 1½ in. Tire, 1½ in., the edge bevelled off, showing a flat surface of 1½ in. Springs, 5 plates, 2 in. steel. C-springs, 6 plates, 1½-in. steel. Axles, 1½ in., Collinge pattern. Fifth-wheels, full circle, 22 in. diameter.

Plates XXXI. and XXXII.—Eight-Glass Landau. Exhibited by Messrs. Petry, Geissel, Bayha & Co., New-York.

This carriage is a new pattern, in that the glass quarters are made applicable, and when desired the glass is removed and the top folded down, as shown in the accompanying drawings on page 578, in which we show the top closed and opened, displaying the position the top assumes when folded down—the back and head resting on the loop, where it is held firmly by locking the back and head with the same lock that holds them in place when the top is in position. The glass at the back drops into a berth at the back of trimming when folding the top. No joints are used to hold the top in an upright position, it being fastened by locks at front and back, and by catches at the centre, holding the whole as firmly together as if made stationary. The front portion of the top is easily raised or lowered, as it has a coil spring attached by a lever to the hinge.

Plate XXXVII.—Vis-à-Vis. Exhibited by Mr. Muhlbacher, Paris, France.

Dimensions.—Wheels, 3 ft., and 3 ft. 10 in. Hubs, 6 by 8 in. Spokes, 1⅜ in. Tire, 1½ in., rounded on the thread. Springs, 1½-inch steel, 5 plates front, 4 plates back. Axles, 1⅜ in., Collinge pattern, and set cornerways, which gives additional strength to the axle.

Plate XXXVIII.—J. B. Brewster Side-Bar Wagon. Exhibited by J. B. Brewster & Co., New-York.

We illustrate J. B. Brewster & Co.'s top side-bar wagon, hung on their improved combination springs and bar, being their most popular style. The combination consists of four half springs, two at the back and front axles, and two connecting with the bars and the body in place of bars or loops, making a very easy and pleasant riding wagon, with no side or end motion. It hangs very low, the perches being bent at the front, passing under the fifth-wheels and into the head block, thus having them sufficiently depressed to avoid the striking of the body and the perches.

Plate XXXIX.—Eight-Spring Victoria. Exhibited by Brewster & Co., New-York.

Dimensions.—Width of body at front of arm-rail, 32 in.; back, 42 in. Turn-under, 4 in. Wheels, 2 ft. 9 in., and 3 ft. 9 in. Hubs, 6 by 8 in. Spokes, 1⅛ in. Tire, 1⅛ by ¼ in. Springs, 4 plates, 1¼-in. steel; C-springs back, 5 plates, 1¼-in. steel; front, 4 plates, 1¼-in. steel. Axles, 1⅛ in., Collinge pattern.

Plate XLI.—Curtain-Quarter Rockaway. Exhibited by J. Colyer & Co., Newark, N. J.

Dimensions.—Width of body at hinge-pillar, 43 in.; back, at arm-rail, 36 in.; front of bracket, 27 in. The bracket is well contracted from the front of seat. Turn-under, 2½ in. Wheels, 3 ft. 5 in., and 4 ft. Hubs, 4 by 7 in. Spokes, 1½ in. Axles, 1½ in. Springs, 1½-in. steel, 4 plates, 36 in. long.

WOOD-WORKING MACHINES AT THE EXHIBITION.

GREENLEE'S RELISHING MACHINE.

THE machine for relishing and mortising doors, sashes, and shutters, by Greenlee Brothers & Co., of Chicago, performs several important processes. Three operations can be performed by this machine simultaneously, and without interfering with each other. The door-relishing is done with the fine circular saws shown on the cut, the three larger saws first making the incisions, when the smaller saws are brought down by the action of the foot-treadle to make the cross-cuts. The mortising of the bottom rail of sashes is accomplished at one operation, by means of a hollow square chisel following the bit which works through it, thus making a square hole as easily as a bit does a round hole. Shutters are relished and the hole made for the rod at one operation. This is applicable to shutters or blinds which are made with movable vanetians or lower boards. Messrs. Greenlee also exhibit some very useful frames for clamping doors, sashes, and shutters while putting them together, the pressure being obtained by means of foot-levers.

The display of American saws, axes, and other wood-cutting instruments is one of the finest in Machinery Hall, and at the same time it is one of the most ornamental, as the highly-polished saws, some of great size, tastefully arranged on large screens, make a glittering show. The difference in the form of the American and English tools, especially in the teeth of the saws, is very marked.

BOULT'S CARVING MACHINE.

Boult's carving, moulding, panelling, and dovetailing machine is a remarkably ingenious contrivance for performing all sorts of operations on one machine, and it is very readily adjusted to execute this great variety of work. When used for edge moulding and shaping the upper arm is not required, the work being performed by the cutter which rises through the table. When surface moulding and panelling are required, the work is held down by means of a disk screwed down through the upper arm, and the rapidity with which a copy of a moulded sunk panel can be executed by this machine is wonderful. By driving cutters from the upper arm, the most delicate scroll, basket, or fret work can be executed, and with the dovetailing attachment excellent dovetails can be produced, cutting the side and front of a drawer or chest at the same time. Boult's machine can be used exclusively for dovetailing if desired. Boult's saw-bench is also well worthy of notice. The table for a circular saw sits on a central trunk, and can be set at any level corresponding with the diameter of the saw used, without changing the length of the belt from the counter-shaft. The table is furnished with sliding gauges for blocking, squaring, cutting bevels or mitres, and the fence can be set at any angle; the bearing of the saw-shaft is cast with an oil-well to hold a pint of oil, and an adjustable throat is provided through which the saw works, and by removing it easy access can be obtained to the screw-shaft. These improvements in the saw-bench are exceedingly simple, and can not be shown readily by drawings or easily described; but any person seeing the bench must be struck by the great utility of Mr. Boult's additions. The fence round these machines was entirely executed by them, and visitors can form a good idea of the great variety of work they can perform by examining the fence, which is exceedingly handsome.

BURT'S SHINGLE MACHINE.

Burt's 12-block rotary shingle machine (Evart's patent) is for producing shingles or thin slabs of wood, largely used in this country for roofing purposes. It consists of a horizontal revolving wheel 8 ft. in diameter, with twelve compartments. Into these compartments blocks of wood, sawn to the length and breadth desired, are thrown loosely. Two circular saws, 38 in. in diameter, are placed horizontally under the revolving wheel, and as each compartment containing a block approaches the edge of a saw, a toothed dog is projected from the centre of the wheel, and presses the block against the rim by means of a weighted lever, which travels over a plate arranged with gradual and steep inclines, in order to regulate the position of the teeth; as soon as the block has passed over the saw and a shingle has been removed from it, the tooth is withdrawn, and the block can be removed or readjusted in readiness for another cut. The revolving wheel is driven by friction, and is readily controlled. The wheel is provided with adjustable dogs, so that shingles 16 in. and 18 in. in length can be cut, and with parallel or tapered sides. It is stated that with good timber 150,000 shingles can be produced with this machine in ten hours by a man and a boy. The same firm exhibit another form of shingling machine with a reciprocating instead of a revolving motion, and only operates upon one block at a time.

WALKER'S SCROLL SAW.

In Walker Brothers' improved scroll saw the straining arrangement is intended to produce an even tension at all parts of the stroke, both upwards and downwards, by the improved form of the spring and friction link; the former can be readily slackened and thrown out of work by a screw in front of the machine, and a blower is provided for removing the sawdust from the table.—*The Engineer.*

HOW TO BUILD CHEAP BOATS.

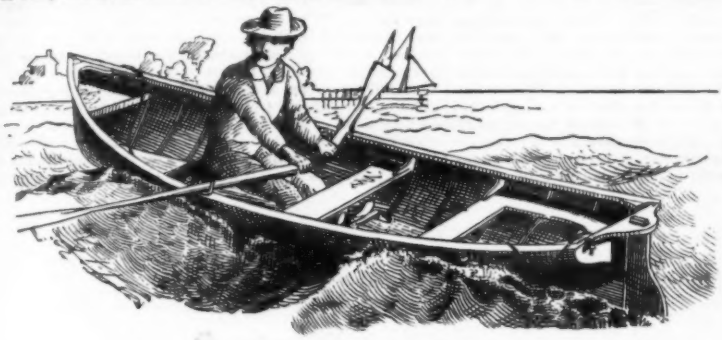
By PADDLEFAST.

NO. VI.—THE FIFTEEN-DOLLAR WHITEHALL ROW-BOAT.—LENGTH, SIXTEEN FEET.

WHITEHALL boats are excellently adapted for rowing, yet safer and more convenient and commodious than shells.

The depth of keel seldom exceeds 1 inch below the bottom, yet a small sail is often carried, and the boat being long and narrow makes little leeway. As the sail on these boats is auxiliary, and chiefly used in a fair wind, such depth of keel should not be exceeded.

This boat will easily carry eight persons. Draught, with that load, about 8 inches. The cost of materials will be about $15. Cost of oars, anchor, material for sail, etc., $10 additional.



FIFTEEN-DOLLAR WHITEHALL ROW-BOAT.

CONSTRUCTION.

Except in the cases mentioned, the construction and dimensions of this boat are the same as of boat 5.

The model departs from the former, and the three tables for the working drawing are accordingly given. The horizontal lines of the working drawing are 3.04 inches apart.

Table 1.

	I.	II.	III.	IV.	V.	VI.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Rib ⊕	13 96	18.96	21.92	23.36	24.24	....
" A	12.00	17.60	20.80	22.80	23.60	....
" B	9.76	15.20	18.56	20.80	22.16	....
" C	7.60	12.32	15.00	18.00	19.68	....
" D	5.36	9.20	12.24	14.48	16.56	....
" E	3.76	6.56	9.12	11.20	12.96	....
" F	2.24	4.24	6.08	7.68	9.20	....
" G	1.12	2.32	3.44	4.56	5.76	....
" H	.24	.72	1.20	1.84	2.48	....
" 1	12.72	18.64	21.52	23.12	24.16	....
" 2	10.64	16.72	20.00	22.16	23.20	....
" 3	7.60	13.44	17.44	20.24	21.60	....
" 4	4.40	10.40	14.24	17.52	19.36	....
" 5	1.92	5.84	10.24	13.92	16 56	....
" 6	....	2.48	5.84	9.60	13.20	15.60
" 7	....	....	2.08	5.28	9.20	12.88
Stern	....	....	....	1.04	4.16	9 44

The groove or rabbit begins to curve upward at frame 4; at frame 5 its upper edge is 1.12 inch above the upper surface of keel; at frame 6, 3.2 inches; at frame 7, 6.4 inches; at inner surface of stern (which is the surface shown on working drawing), 10.8 inches.

Table 2.

Rib ⊕	16.96 in.
" A	17.04 "
" B	17.60 "
" C	18.40 "
" D	19.04 "
" E	20.64 "
" F	22.00 "
" G	23.52 "
" H	25.04 "
Stem	26.96 "
Rib 1	17.12 "
" 2	17.68 "
" 3	18.32 "
" 4	19.20 "
" 5	20.16 "
" 6	21.12 "
" 7	22.00 "
Stern	22.96 "

Table 3.

Rib ⊕	24.48 in.
" A	24.16 "
" B	23.04 "
" C	21.12 "
" D	18.56 "
" E	15.52 "
" F	12.32 "
" G	8.48 "
" H	4.64 "
Stem	.... "
Rib 1	24.48 "
" 2	23.68 "
" 3	22.40 "
" 4	20.64 "
" 5	18.80 "
" 6	16.80 "
" 7	14.80 "
Stern	12.80 "

Dimensions (*Fig.* 36).

f	28.46 in.	*p*	1.5 in.
g	12. "	*q*	24.46 "
l	8. "	*a*	.51 "
k	5.2 "	*r*	12.4 "
m	to frame 4. "	diagram 8, *c*	.26 "
n	2. "		

	Diagram 1.	*Diagram* 3.	*Diagram* 7.
	Inch.	Inch.	Inch.
F	....	....	1.6
G	....	....	1.6
u	.5	.5	.5
v	.5	.5	.75
w	1.	1.	2.44
Thickness of G or H at junction with F	.5	.5	.72

	Assuming diagram E to represent cross-section of keel at frame H.	Assuming diagram E to represent cross-section of keel at frame F.	Assuming diagram 3 to represent cross-section of keel at frame 6.	*Diagram L.*
	Inch.	Inch.	Inch.	Inch.
a	.04	.30	.39	.36
b	.75	.9	1.	.75

Frame 7 is	8.	in.	from stern.
" 6 "	8.8	"	" frame 7
" 5 "	9.6	"	" " 6
" 4 "	11.2	"	" " 5
" 3 "	11 6	"	" " 4
" 2 "	12.8	"	" " 3
" 1 "	13.6	"	" " 2
" ⊕ "	13.6	"	" " 1
" A "	13.6	"	" " ⊕
" B "	13.6	"	" " A
" C "	13.6	"	" " B
" D "	12.8	"	" " C
" E "	11.6	"	" " D
" F "	11.2	"	" " E
" G "	9.6	"	" " F
" H "	8.8	"	" " G

Dimensions of Ribs.

	Length.	Width of lower end.	Width of upper end.	Thickness throughout.
	Inches.	Inch.	Inch.	Inch.
⊕	69	.8	.5	.5
A	67	.8	.5	.5
B	63	.8	.55	.5
C	61	.8	.59	.5
D	59	.8	.62	.5
E	55	.8	.65	.5
F	53	.8	.67	.5
G	53	.8	.7	.5
H	53	.8	.75	.5
1	69	.8	.5	.5
2	67	.8	.54	.5
3	63	.8	.56	.5
4	61	.8	.58	.5
5	59	.8	.60	.5
6	53	.8	.63	.5
7	47	.8	.64	.5

Bevel of Ribs at Top.

Rib ⊕	.00 in.	Rib 1	.00 in.
" A	.00 "	" 2	.04 "
" B	.05 "	" 3	.06 "
" C	.09 "	" 4	.08 "
" D	.12 "	" 5	.10 "
" E	.15 "	" 6	.13 "
" F	.17 "	" 7	.14 "
" G	.20 "		
" H	.25 "		

Bow-seat, 20 inches long.

Forward edge of thwart A, 4 feet from bow.

Forward edge of thwart B, 3 feet 4 inches from forward edge of thwart A.

Forward edge of thwart C, 3 feet from forward edge of thwart B.

The mast is placed in the centre of thwart A, Fig. 58, and enters a mortise in the middle board of the ceiling. This board should be well fastened in consequence.

To promote lightness, the boards of the ceiling may be narrow and placed an inch or more apart.

The sail of a Whitehall boat is usually furled against the mast, thus avoiding the use of halliard, block, and wooden hoops. In this case the boom is either used like a second sprit, as shown by W, Fig. 34, or with the sail lightly tied to the boom, and the end of the boom placed in a becket on the mast. When the sail is furled it is untied from the boom.

By the latter arrangement the sheet may be fastened to the boom, near the middle, a more convenient position for the sheet than that necessary in Fig. 34. The sail is better spread also.

The sail is so small that traveller and block are not necessary. The sheet is about 14 feet long. The sheet and the tiller rope should be of white cotton—that substance being softest for the hands—and sufficiently large to be easily grasped.

Spars.

Length.	Diameter.	
Mast	10 feet 4 inches.	At butt 2.2 inches.
Boom	11 " 4 "	" head 1.3 "
Sprit	10 "	" middle 1.5 "
		" " 1.3 "

Sail: height on mast, 7 feet; length on boom, 10 feet 8 inches; rise on boom, 2 feet 4 in.; peak, 11 feet 10 inches high on a vertical line, and 3 feet 9 in. abaft the mast on a horizontal line; or, referring to Fig. 26, the peak 1 is 4 feet 10 inches above the mast on the vertical dotted line, and the distance on the horizontal dotted line marked "4" is 3 feet 9 inches.

In SUPPLEMENT No. 29 direction was given to hem the sail on the edge, and in the hem to run a cord. That process was described because it was the easier; but a more effective and durable method of strengthening the sail is to hem the edges as before, making a somewhat narrower hem, and then sew a hemp rope .5 inch in diameter to the edge, on the outside. The needle is passed between the strands. On the "leech" (the side of the sail extending between the aft end of the boom and the peak) the rope is untwisted slightly as it is sewed on.

Fig. 62

In this boat the steersman must sit nearly amidships to maintain an even keel. In this position a tiller is useless, and the contrivance shown in Fig. 62 is employed. A is the rudder-head. B is the "yoke," which fits crosswise upon the rudder-head, allowing the hole in A to rise above the yoke. A pin is then placed in the hole to secure the yoke, and tiller-ropes are run through the holes at the ends of the yoke and knotted.

The yoke is cedar, about 15 inches long and .75 inch thick. The mortise is 2.5 inches long, and runs across the yoke. The tiller-ropes should run to thwart B.

A canoe will be next described.

A person desiring a smaller craft than the Whitehall boat last described, but of the same build, may divide the measurements given in tables 1, 2, and 3 by ¾, and make a working drawing of a boat 3 feet wide; also dividing the distances between the ribs by ¾, making the whole length 12 feet. The lengths of the ribs are to be divided, and the other dimensions thereof slightly reduced, but the bevels are unaltered. There would be room for only two thwarts. The stern-sheets and the bow "cuddy" may be made or not as desired. This would make an excellent small row-boat.

Of course the builder may in the same manner vary the proportions of other boats described, to more fully suit his wants.

SIMPLE RULES FOR THE MANAGEMENT OF SAIL-BOATS.

THE following brief rules are applicable to cat-rigged boats, row-boats fitted with one sail, and others of the small size generally employed for pleasure purposes. They are thoroughly well known to experienced boatmen, but the very frequent capsizings, collisions, and similar often fatal accidents which occur to amateurs are perhaps in the majority of cases due to their neglect:

1. Never belay a sheet with a jamming hitch. When the boat manifests any especial crankiness, or has a reputation for that fault, do not belay it at all, but hold it ready for instant letting-go. It is safer, in any event, if the weather be at all squally to take but a single running turn of the rope about the cleat, keeping the end in hand.

2. Never climb the mast of a sail-boat. If the halliards foul, unstep the mast and clear them. The weight of the body at the end of the pole acts with a powerful leverage to upset the hull. We have known large and heavy ships' cutters capsized in this way.

3. A squall exercises its worst effect when it strikes a boat right abeam. Therefore, if the gust comes on the quarter, do not try to luff, but start sheet and run before it. If it strikes forward the beam, luff; and when the sail flaps, ease away the halliards and reef. In case a boat heels under a strong gust and is slow to recover, start the sheet.

4. When the wind is irregular and liable to come in swift, sudden puffs intervening with gentle breezes, reef the sail.

5. Never enter row-boats and others that are lightly built other than by stepping carefully amidships. It is dangerous to step on the gunwale or on the side-planking. It is a safe rule when a person enters a boat thus carelessly, and loses his balance, through the heeling of the boat, to throw himself flat on the bottom and pull it down with him.

6. Where a boat is known to be crank, the occupants should sit on the bottom. This often greatly adds to the stability of the vessel.

7. Too great care can not be exercised in passing under the lee of large vessels or bluffs. The sudden puff of wind which is afterwards encountered, and which fills the boat's sail—for the moment before becalmed—if not guarded against, is very apt to cause an unlooked-for capsize.

8. Should a boat spring a leak, bringing the wind on the damaged side and carrying weights to leeward will often heel the boat sufficiently to raise the hole out of water, when it can be plugged with such means as may be at hand. In case this is impracticable and the water gains rapidly, take a coat, tie a piece of rope to the collar and another to the tail, and pass it under the bow, the ropes coming up on each gunwale. Carry it aft until it reaches the leak, when the entering water will force it inward. Secure the ropes tightly, and run for the nearest land or shoal. It is rarely possible that a leak can be plugged from within the boat.

9. In case a strong wind is dead against you and is blowing you out to sea, or in case nightfall comes on and the bearings of land are lost, unstep the mast, unbend the sail, and make a bundle of the mast and oars, together with the seats, if loose, lash all firmly together, fasten the boat's painter to them, leaving as much as possible of the latter between bundle and boat, and throw the former overboard. The boat will ride to her spars, which will form a sea-anchor, and will remain head to the wind. Unless in a strong current, she will drift but little before daylight, or until a moderation of the wind (which usually comes with sunset) occurs.

10. The rules for avoiding collisions for sail-boats are few and simple. When two boats both close to the wind on opposite tacks meet, the helms of both are put to port. This is precisely the same rule of "keep to the right" followed by carriage-drivers ashore. Boats sailing free must give way to those close to the wind. Where both are sailing in the same direction, it is the obvious duty of the sternmost to keep from running into the one ahead. Steamers and boats under oars are obliged to give way to all sailing craft, but sail and small boats generally are expected to keep well clear of large sailing vessels. Where a collision can not be avoided, both boats should put their helms so that the blow will be given and received at as great an angle as possible, and after the shock the two should be fastened together until it can be ascertained whether any dangerous damage to either has been done.

11. In tacking, ease the helm down gently, and the boat will probably shoot considerably into the eye of the wind in going around, and thus gain. To jam the helm suddenly down is merely to deaden her way, without any corresponding advantage.

12. Jibing—that is, luffing, when sailing with the wind well aft, so as to swing the sail over on the other side—is at best a risky manœuvre. In strong winds the sudden swing of the sail is apt to wrench the mast-head severely, and if it be abruptly checked, the tendency is to capsize the boat. The best way is to move the helm gradually, and as soon as the sail shows a desire to come over, help it by gathering in the sheet, so that when the boom does swing it can do so over a very short distance, while it can be eased off by slacking the sheet rapidly.

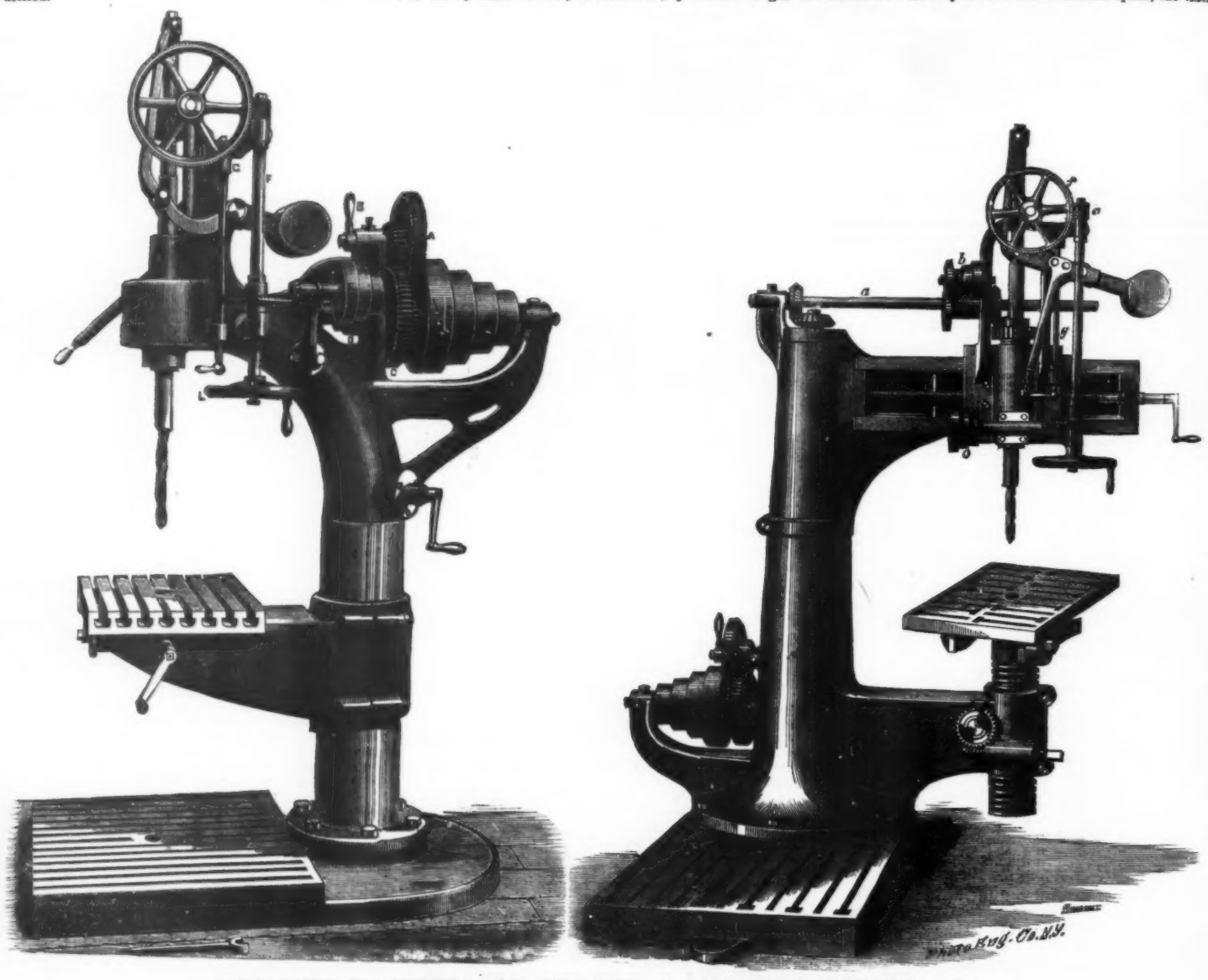
13. A sail-boat carrying a jib can be hove-to (rendered stationary) by hauling the jib-sheet over to windward, which tends to pay her off, and putting the helm down so as to counteract this. Cat-boats usually haul their main-sail sheet flat aft, and keep the sail shaking, meeting, with the helm, any tendency of the latter to fill.

14. Never try to beat against an adverse wind and tide. Better anchor and await a change.

DRILLING MACHINES.

By Messrs. W. B. BEMENT & SON, Industrial Works, Philadelphia, Pa.

THE first of these, represented by the left-hand figure, is a drilling machine *k*, which presents several specialties of detail. The drill is made to revolve by means of bevel gearing on the head of the spindle, and on the pulley-shaft which passes through the frame of the machine. The spindle can be driven either direct through the pulleys or through the gearing marked *a*, which can be put into gear by throwing over the lever *b*. A strap from the pulley *d* passes over *e*, and drives the feed motion, which consists of a bevel pinion, driving a wheel on the vertical spindle *f* carrying a worm at its upper end. This spindle is supported by two bearings *g* and *h*, which are free to move slightly in guides, and by turning the spindle *i* sufficient motion is given to the spindle *f* to throw the worm at the upper end free of the worm-wheel. The spindle may then be thrown up or down by means of the lever *k*, a series of levers and a counterbalance being provided to facilitate this operation. It will be seen that on the shaft of the worm-wheel is a pinion gearing into the rack on the upper part of the spindle. By this means the latter is raised and lowered, or, when desired, the drill may be actuated by the hand-wheel *l*. The upper table may be thrown round out of the way when greater space is required for the work to be drilled.



DRILLING MACHINES, BY BEMENT & SON, PHILADELPHIA, PA.

The second is a radial drilling machine, the arrangement of which will be clearly understood from the engraving.

The position of the head carrying the drill and attachment upon the radial arm is regulated by a screw as shown, and the drill-holder is driven from the coned pulleys at the foot of the pillar, different speeds being obtained by gearing as in the fixed drill. The pulley-shaft carries a bevel-wheel which gives motion to a vertical shaft in the pillar, and having a bevel-wheel at the upper end. The latter gives motion to the horizontal shaft *a*, and this through the system of gearing shown to the drill-spindle. A strap passing over the coned pulleys *b* and *c* feeds the drill down through the bevel gearing *d* and the worm and worm-wheel *e* and *f*. As in the fixed drill the worm *e* may be thrown out of contact with the wheel by turning the spindle *g*, and the drill-holder may be thrown up and down by the lever *h*. As shown in the engraving, the drill is provided with a small table carried by an arm from the main standard, and capable of being raised or lowered by a screw, as shown, while a larger fixed table for heavy work forms part of the base-plate on which the standard is fixed. The drill, it will be noticed, can swing completely round, the turning portion of the former being shaped so as to form apparently a continuation of the fixed standard. The whole design is exceedingly neat.—*Engineering.*

WHAT MAKES THE RADIOMETER TURN?

Views of M. G. A. Hirn.—The attention of the scientific world has been latterly drawn to the singular phenomena which Mr Crookes has studied with the radiometer. The conclusion which has presented itself to the mind of many is that these phenomena are due to an impulsive action of the luminous rays, and that it is thus demonstrated that light is a movement of ponderable matter. Nevertheless, the phenomena discovered by Mr. Crookes have been elucidated, if not in their cause, still in their form and their starting-point. The ingenious counter-proof to which M. Arthur Schuster has submitted them places it beyond doubt that it is by no means the direct action of the rays emanating from the luminous source which determines the movement of the disks of the radiometer, but that the repulsive power here called into play has its seat in the walls of the transparent vessel which serves to contain the mill, and that this power is set in action by the pencil of rays directed upon the apparatus. As the true explanation of the totality of the phenomena has not yet been given, and as the hypothesis of the materiality and of the impulsive force of light will probably not soon be abandoned, the author thinks it useful to submit this hypothesis to the test of the method of successive elimination. M. Crookes has calculated the apparent repulsion exerted by the solar rays at 1 grm. per square metre. This pressure is more than one thousand times greater than the maximum value possible for reflecting bodies, and more than two thousand times superior to the maximum value possible for absorbing bodies We may, then, affirm that the phenomena which Mr. Crookes has made known are nowise due to the effect of an impulsion of light, and do not imply the idea of mass of density as regards radiant light and heat. However carefully the vacuum in the vessel inclosing the radiometer or torsion balance may be made, there remain, nevertheless, quantities of gas or vapor relatively enormous. The maximum pressure which the solar radiation can exert upon 1 square metre of absorbing surface is 0.0004157 grm.: let us suppose that the disks of the radiometer are ten square centimetres, the maximum pressure upon them will be 0 000004157 grm., or a little more than $\frac{1}{100000}$th of 1 grm. The slightest agitation of the small quantity of gas remaining in the apparatus will produce upon the radiometer pressure comparable to this. However transparent may be the glass case of the radiometer, it still absorbs a part of the calorific or luminous rays; one of its surfaces is heated more rapidly than the other. This inequality of temperature necessarily determines electric polarity, or the manifestation of static electricity. The vacuum, it is said, is so perfect that the electric spark cannot traverse the apparatus. But electric attractions and repulsions traverse the vacuum. However feeble may be this cause of attraction and repulsion, it may nevertheless have a considerable value in comparison with our maximum of 0.000004157 grm.

Views of M. A. Ledieu.—The author's experiments become less and less favorable to the theory of the apparatus based upon the movements of gases and vapors remaining within the glass case after the vacuum has been made. This theory, as we know, is subdivided into various doctrines, of which a very complete and lucid exposition has been given by M. Bertin in the June number of the *Annales de Chimie et de Physique.* The capital objection which mechanicians oppose to these different explanations is, they are all reduced to admit, that the radiometer is an instrument of reaction. But in such apparatus, having regard to the impossibility of the motive power being rapidly produced with a sufficiently constant intensity, there ensue merely rotations accompanied by retardations and bounds far from being reconcilable with the perfect regularity of the radiometer. Moreover, the theory in question expressly requires that there shall never be an equilibrium of temperature between the gas in the case and the disks of the radiometer. But how are we to admit that in every experiment this equilibrium is not ultimately established? Moreover, the rotation ought to stop at last instead of maintaining itself indefinitely at the same speed. The author then cites certain experiments difficult to explain by the supposed movement of gases in the interior of the apparatus. Thus the instrument was heated nearly to redness, when it commenced turning, but the rotation was sensibly accelerated by the momentary presence of a single flame, which joined its action to that of the radiant heat. An apparatus was constructed with disks exclusively polished. On throwing a pencil of solar rays upon one of the two hemispheres of the glass case a perfect rotation was obtained, without interruption, and as free and rapid as with an ordinary radiometer fully exposed to the light. The author bases his explanation of the phenomena upon a mechanical action of the "ether" perpendicular to the direction of its rays of propagation, and not in the same direction as these rays. This interpretation is calculated to calm the legitimate disquiet of the partisans of undulation. In Germany there is a leaning to an explanation based upon electricity. They rely upon the experiment that when a radiometer with disks exclusively polished, and where one of the hemispheres of the case is traversed by a continuous electric spark, the instrument takes a rapid rotation, always opposite to the direction of the spark, this direction being understood according to the common convention. "In any case the radiometer of Mr. Crookes seems to us a serious instrument, and not a parsdoxical apparatus destined to enjoy an ephemeral scientific repute and then to rank as a mere physical amusement. Its experimental study, pursued under all modifications and with an indefatigable perseverance, will certainly lead to important results as to the mechanical properties of the ether."

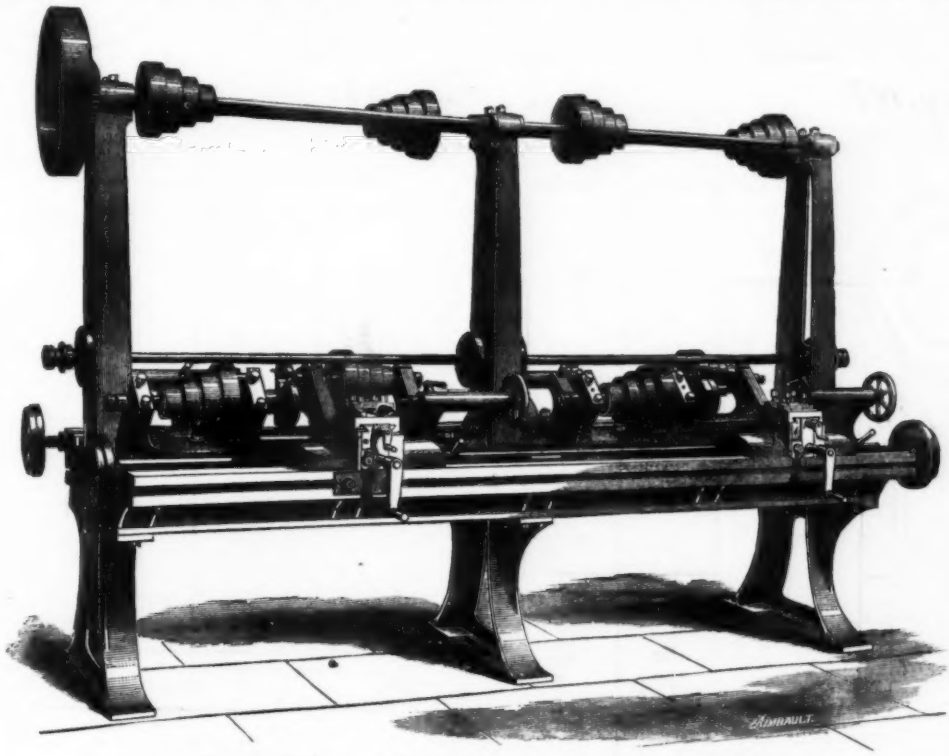
Views of M. G. Salet.—The author makes the disks of his radiometer of mica, and blackens both on the same side. He considers his results difficult to reconcile with the idea of a direct impulse due to light or to the ether, but contrary to the theory which seeks to explain the movements of the radiometer by the disengagement of gases condensed on the disks. Can the minimum quantity of gas which remains in an apparatus exhausted with such care suffice to occasion the movement, according to Tait's theory?

Views of M. W. de Fonvielle.—The author has had constructed a radiometer, the disks of which (of mica) are coated on both sides with lampblack, and the case is blackened in the same manner over half its surface. If the light is received perpendicular to the diametral section which separates the transparent hemisphere from the darkened hemisphere the apparatus remains motionless. If, on the contrary, the diametric plane is inclined to the left, the left-hand disks, more strongly illuminated than those on the right, are repelled more energetically, and the radiometer takes a regular movement from left to right. The same phenomenon is observed in the inverse direction if the diametric plane is inclined to the right. The rotation is the most rapid possible when the diametric plane is rendered parallel to the rays of light which illuminate the apparatus.

COMBINED SELF-ACTING SLIDE LATHES.

WE illustrate a very neat arrangement of self-acting slide lathes with 7¼ in. centres, constructed by Messrs. Shaw, Hossack & Co., of Openshaw, Manchester. As will be seen from our engraving, there are four lathes arranged in one group, there being two beds mounted upon three standards, which are prolonged upwards, so as to carry the top driving gear. The beds are three-ribbed, and there are two complete lathes upon each bed, the headstocks, which are fitted with steel spindles and brass step-bearings, being overhung so as to allow of the carriages passing them.

The carriages and beds are arranged for sliding articles to forms determined by shaper-plates, the carriages being maed to hinge upon two centre-ribs upon the beds, which are directly under the centre-line of headstock spindles. The carriages



COMBINED SELF-ACTING SLIDE LATHES.

are provided with pointers at the back, which follow the outline of the shaper-plates, and thereby actuate the carriages, the raising of the front of the carriages by the shaper-plates causing the tools to be canted inwards, and thus reducing the diameter of the article which is being turned. The shaper-plates are fastened to the beds by means of bolts fitting in a planed **T** groove running the whole length of third rib of each bed, and adjustable along the latter.

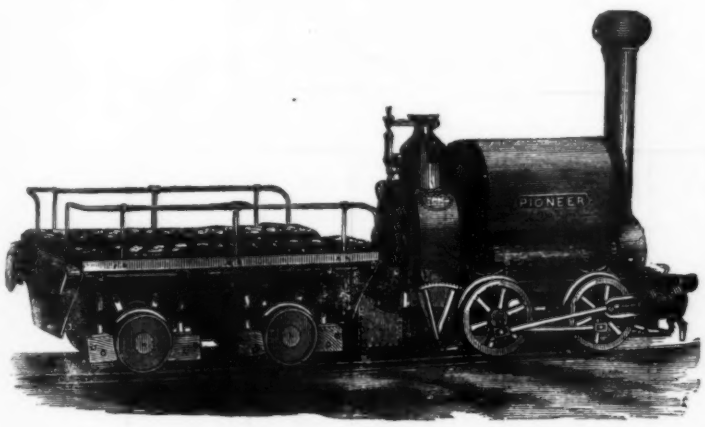
The lathes we illustrate are specially adapted for sliding straight work, or for sliding to shaper-plates articles of different forms, and they effect a great saving where there are a number of articles of the same form to be turned, such as recessing the centre portion of locomotive fire-box copper stays, tapering boiler-tube ferrules, etc. The whole arrangement is thoroughly well carried out, and it is one we think likely to meet with considerable favor.—*Engineering.*

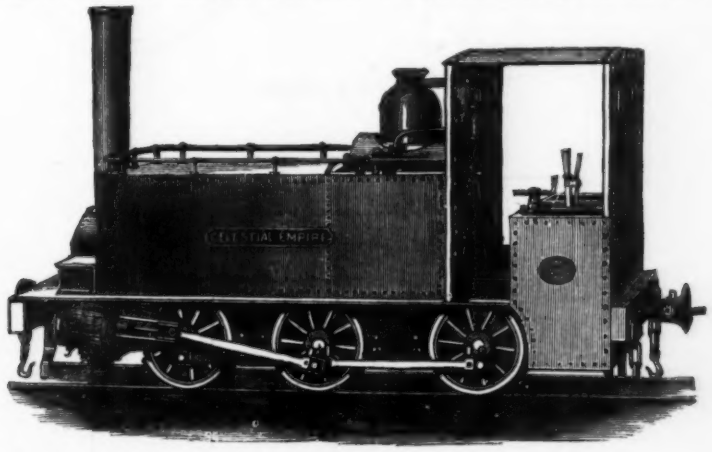
THE CHINESE RAILWAY LOCOMOTIVES.

A RAILWAY IN CHINA.

THE Celestial Empire has at length become the scene of railway operations, and, although only on a small scale at present, it leads to the hope that the present may prove the precursor of many lines. The question has been agitated for some years past, the Chinese proving very difficult to be persuaded of the advantages of the railway system. In 1873 it was proposed to subscribe for a short line of railway which was to be made and presented to his Majesty the Emperor The scheme was well supported here, and was warmly discussed when the Iron and Steel Institute visited Liège in 1873. At this time Mr. R. C. Rapier, of the firm of Ransomes & Rapier, of Westminster and Ipswich, had a special audience of the King of the Belgians upon the subject, and the leading members of the English and Belgian iron trades gave their adhesion to the project. But it fell through on account of political reasons which interfered to prevent the consummation of the plans. There were, however, some gentlemen who were moving in another direction at the same time, and offered for placing it upon Messrs. Jardine's proposed line, and it was forthwith sent to China. That arrangement having been settled, Mr. Rapier prepared the estimates for a cheap line of railway with a 2 ft. 6 in. gauge, and a station at Kangwan, a point midway between the two termini. The estimate was 30,000*l.*, and the contract was let to Mr. John Dixon, of London. The line was commenced in January last, and has been constructed from Shanghai to Kangwan—half its length—and thus far it was opened on the 30th of June, 1876. The remainder of the line is well advanced, and is expected to be opened in a short time. The line was easy to make, being unattended with any engineering difficulties whatever. It is laid with 27-lb. rails of the Vignoles section, on cross-sleepers. The little engine Pioneer, of which we give a perspective view on the present page, was specially built to be the smallest practicable engine to travel 20 miles an hour or to haul 20 tons. The cylinders are 5 in. diameter with a 6-in. stroke. The engine is carried on four wheels, 18 ins. in diameter, all coupled and all fitted with brakes, the wheel-base being 2 ft. 3 ins. It has 35 square feet of heating surface and 1 square foot of grate area, and its weight in working order is 30 cwt. This engine has most completely succeeded in effecting its intended purpose, that of disarming the prejudices of the Chinese, the engine performing really appreciable work, and yet being so small as to cause any opposition to appear quite ridiculous. This primary difficulty was overcome during March and April last, and the larger-sized engines for working the line arrived out in May last, ready for the opening.

These latter engines are two in number, and have been respectively named the Celestial Empire and the Flowery Land. One of them—the Celestial Empire—will be seen illustrated with the Pioneer, in the above engravings. These locomotives were designed by Messrs. Ransomes & Rapier, by whom they were also manufactured. The type of engine was determined on to suit the local circumstances of the line, high speed being of less consequence than good hauling power. The length of wheel-base is 7 ft 6 ins., and the wheels, 2 ft. 3 ins. in diameter, are six in number, all coupled and fitted with brakes. The cylinders are 8 in. diameter by 10-in. stroke. The barrel of the boiler is 2 ft. diameter, the tubes being 1¾ in. diameter and 6 ft. long. The total heating surface is 150 square feet, and the grate area 4 square feet, the weight in working order being 9 tons. The water is carried in side tanks. The boiler and frame are throughout of Low Moor iron, and the boiler is constructed for a working pressure of 200 lbs., but it is intended to be used only up to 120 lbs. This excess of strength of the boiler is to meet any contingencies that may arise at the hands of the Chinese firemen. The railway is fitted with double water-supply tanks at each end of the line, so as to allow the water in all cases one day to settle. In order to fully cover the liability of being short of clean water, the water-tanks of the engines are made large enough to run two double trips. Before being sent away these engines were fully tested, at Ipswich, to four times the maximum duty which they are ever likely to be called upon to perform in China. The trips which these engines have to run being short, the fire will often be brightest at the end of the journey, and the stoppages being long, the engines are provided with extra steam space by having both a high-topped fire-box and a dome, and are also furnished with an extra large Gifford's injector, so as to fill up the boiler quickly when standing. The feed-pump is also of extra size. The frames are ¾ in. thick, and planed all over, the axle-box guides being of wrought iron and riveted on to the frame The springs are hung underneath the axle-boxes. The wheels have steel tires and Low Moor axles. The engines are fitted with all the usual appliances, and have throughout been made with special care, having regard to their important destination. The carriages are first, second, and third class, of substantial construction and plain but neat appearance.





The opening, on the 30th of June, 1876, was highly successful, the Chinese taking readily to what in official quarters was looked upon as an innovation. They were conveyed up and down the line, free of charge, all the day following the opening, and on Monday week the line was opened for regular working. Six trains are run daily each way, and recent telegrams state that they are all crowded with passengers, and that the cash receipts are highly satisfactory. So far, then, the line appears to be a success, and, as the anticipated interference on the part of the authorities has not been manifested, it is to be hoped that the Shanghai line will prove to be the first instalment of a vast system of Chinese railways. Whether regarded from a military or a commercial point of view, there can be no question that railways would prove of immense benefit to that vast and densely-populated country.—*Engineering.*

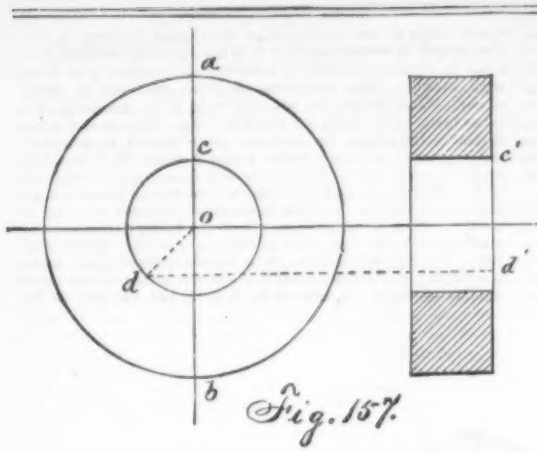


Fig. 157.

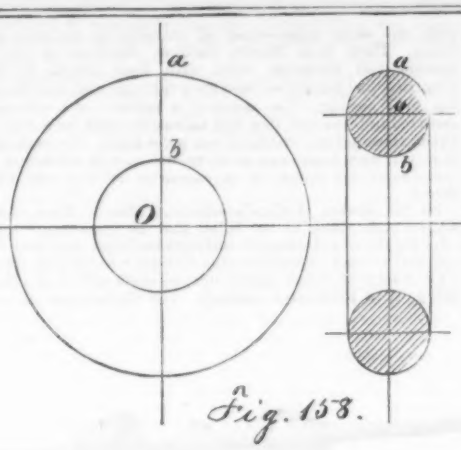


Fig. 158.

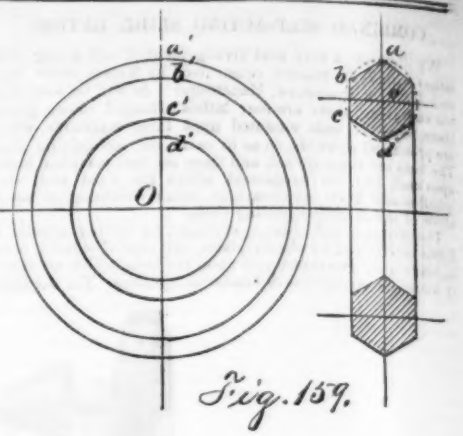


Fig. 159.

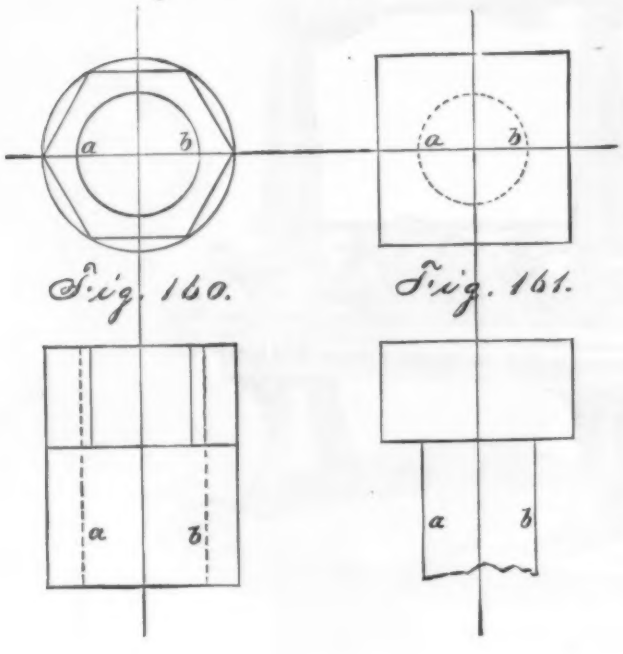


Fig. 160.

Fig. 161.

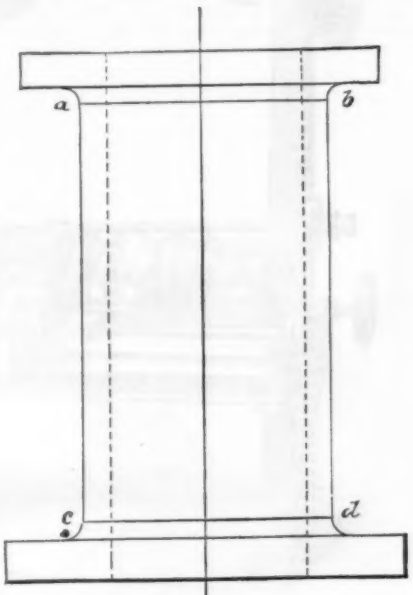


Fig. 162.

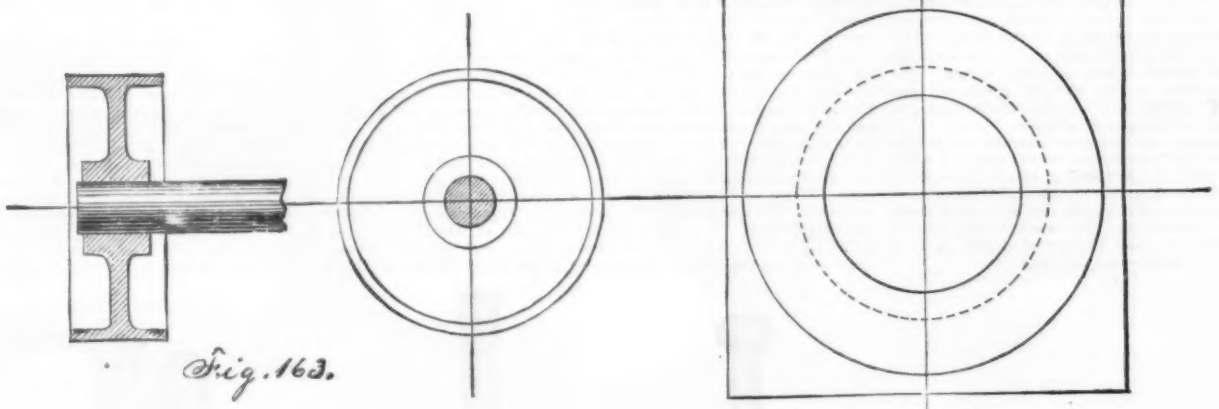


Fig. 163.

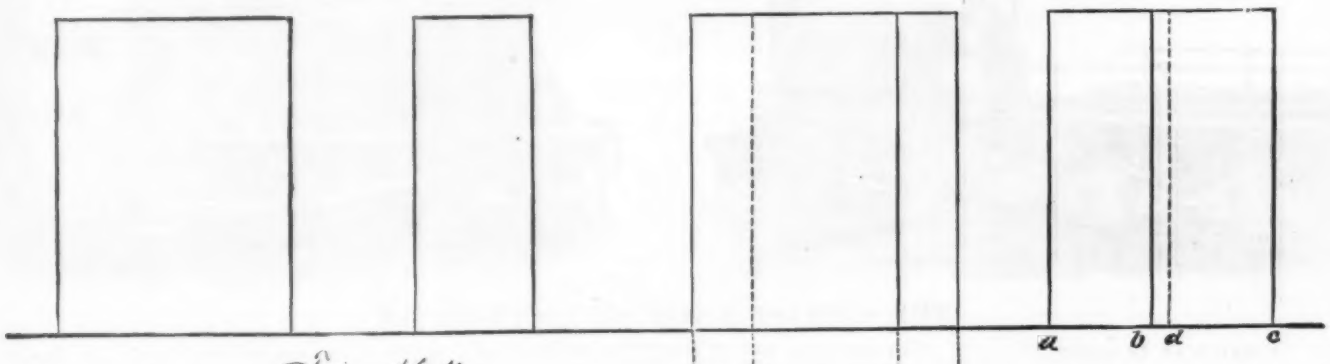
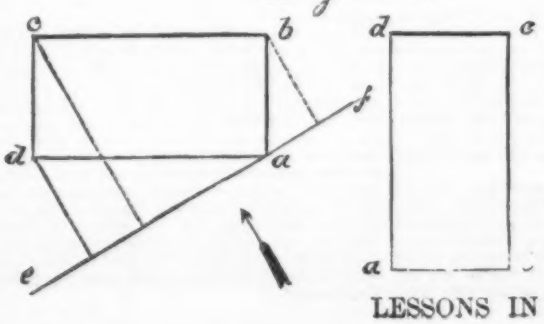


Fig. 164.



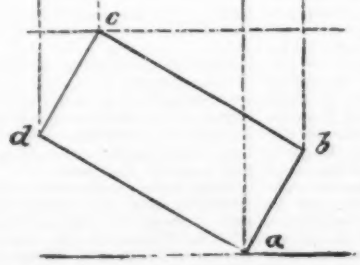


Fig. 165.

LESSONS IN MECHANICAL DRAWING.

LESSONS IN MECHANICAL DRAWING.

By PROF. C. W. MACCORD.

No. XVIII.

(Continued from page 572.)

BEFORE proceeding to the consideration of projections when the object is placed in an inclined position, it is, we think, better that the student should familiarize himself thoroughly with the methods of working them, when, as previously supposed, the principal lines are parallel or perpendicular to the paper. In order to do this, the best method is for him to make drawings of objects of simple forms, bounded by straight lines or circles: it is a good exercise for him to contrive or select for himself, and one who is really in earnest will never be at a loss. If in his efforts he should chance to meet with any thing which has not been explained, he should endeavor to study out for himself a method of making the construction, in which attempt he must never lose sight of the fact that the principles summarized in the preceding lesson are absolutely all that are involved in the form or model of projection now under consideration, and consequently, if he knows the position of each point in the object to be drawn, he ought to be able to fix the projection or representation of every one in either view. We say if he knows, because there are many cases involving intersections of surfaces, as, for instance, a large pipe with a smaller one running into it, in which it is not probable that he will as yet be able to determine the positions of all the visible points.

The logical deduction from the preceding remarks would be, that no further explanation of the processes of making projections is required—that, knowing how to make the different representations of a point, the student is to be left to work out the rest for himself. But we do not propose to abandon him just yet; no doubt it would be possible for him to get on alone, and we may say here that we candidly advise him to do as much as he can without taking too much time, without reference to the explanations of processes of construction; for the mental exercise is a good thing, and what is acquired in that way is sure to be thorough. Still we differ radically with those who hold that text-books should be such as to obscure the subject and compel the student to do all the work, merely proposing problems and giving arbitrary rules without clue to the reasons. Books of that description are suitable for the use of those who are competent to write better ones, who do not need instruction in the subject-matter, but only hints as to what is to be done. As if a guide were to take the tourists a short way into the wilderness, and then say, "Here is the happy hunting-ground, and I know all about it; go you, fish, shoot, and be joyful." The old frontiersman and the born woodsman are not frightened at a bit of new country, and when they have explored it they perhaps know it better than the guide did; but they lose much time, and the others flounder on for a while, and either get lost or turn back disheartened and disgusted.

We take this opportunity, then, to declare that our intentions are honorable. We propose to furnish a complete map, and to make the roads as smooth and free from obstructions or difficulties as we can.

Before going farther, however, we give a few miscellaneous examples involving no principles not already explained. Fig. 157 is a drawing of a ring, or annulus. The front view is precisely like Fig. 113, and we repeat it here for the purpose of showing a *complete* drawing, as it will be seen that Fig. 113 gave no clue to the thickness of the ring, which the side view here introduced defines.

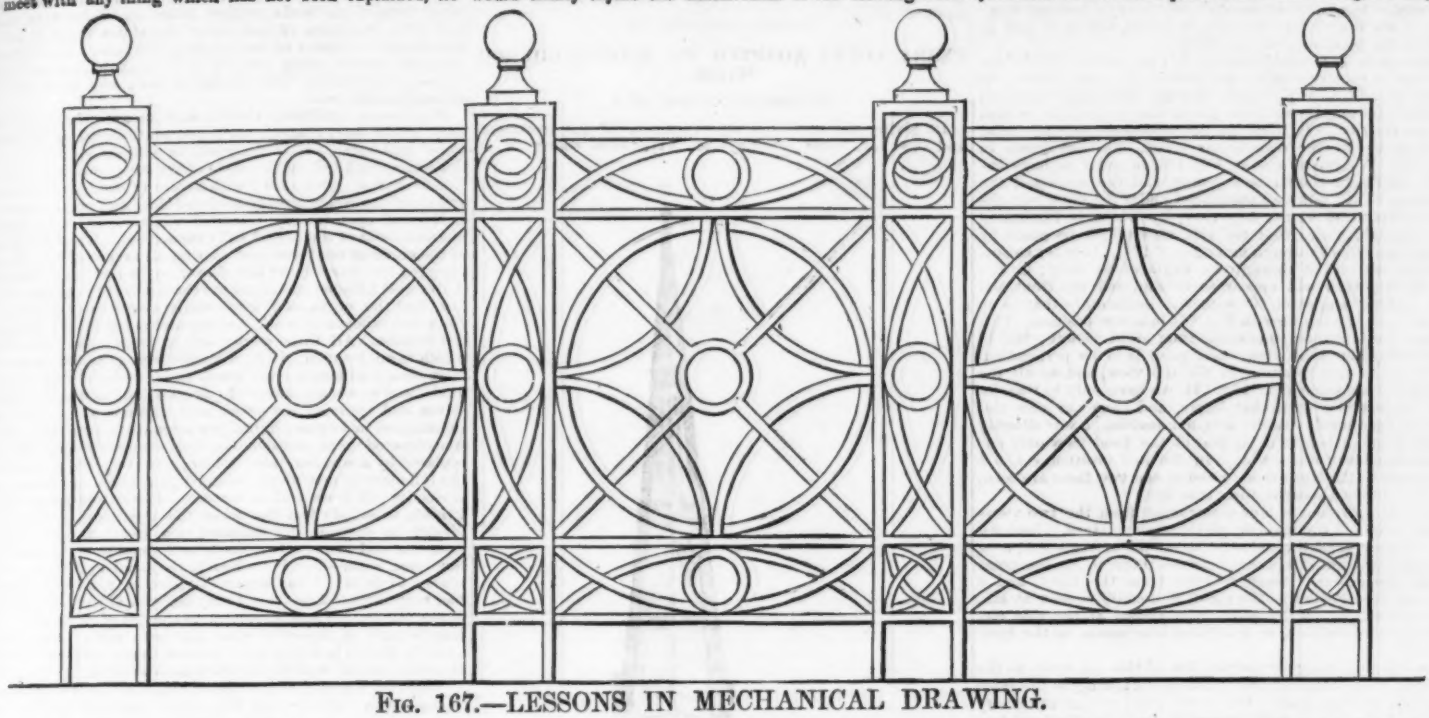


FIG. 167.—LESSONS IN MECHANICAL DRAWING.

It will be observed that this side view does not represent the outside of the ring as it would appear if viewed from the right, but it shows it as it would look if split in the direction of the axis through the line *a b*. Such a view is called a *section*, and it indicates the form more clearly than an outside view would do, for two reasons. One is that all the outlines in this case are full; the other, that in order to distinguish the parts which are cut through from those which are not, they are "hatched," or, as it is technically called, "sectioned," with lines which are not parallel, but inclined to the outlines of those parts.

Now in so simple a thing as this it was not necessary to make a sectional view. We have done it for the sake of explaining what it is, and more particularly for the sake of calling attention to one circumstance in connection with the shadow lines.

This is, that in the side view the shadow lines are placed only on the parts which are sectioned. A little study will show that in reality, since the shadow in the front view does not terminate until we reach the point *d*, going round the inner circle from *c*, there should strictly be a shadow line in the side view extending from *c'* to *d'*. Should be, that is, if we were compelled to introduce a shadow line wherever a shadow actually exists. But we have before said, and we here repeat, that since a shadow line is a merely conventional thing, having no real existence, we are at liberty to use it to the best advantage; to introduce it when it aids the effect we wish to produce, and to subdue or suppress it altogether if it becomes obstreperous. Now in the present instance we are looking at the concave interior of the ring; the parts which are in section are nearest us, and the surface bounded by them recedes, and that abruptly. Under these circumstances the sectioned parts should be given a strong relief, which is done by the heavy shadow lines; and it would clearly injure the effectiveness of the drawing were the receding concavity made to stand out from the paper by the introduction of even a much lighter shadow line, which, therefore, is wholly omitted.

Fig. 158 also represents a ring, but it is such as would be made by bending a cylindrical bar until its axis should become a circle. This is clearly shown in the sectional side view, in which the sectioned parts are circular instead of square as in Fig. 157. In this case the form is such that in neither the front nor the side view are any shadows cast by the outlines, except those of the two circles indicating the form of the section.

A ring of still another form is shown in Fig. 159, the sectional view showing that it would be formed by bending up a hexagonal or "six-square" bar. In the construction it is best to begin by drawing the side view, first describing the circle about *e* (dotted in the figure), inscribing the hexagon, and then projecting the points *a b c d* horizontally to *a b c d* on the vertical centre line through O in the front view, which will be points on the circumferences of the four circles of which that view consists. By applying the 45° triangle to the side view it will be seen that the point *c* is the limit of the shadow in the upper section, which hint will suffice to account for the shadow line on the circle through *c* in the front view; in a similar way, considering the section of the lower part of the ring, the student will find a reason for the shadow line on the other circle.

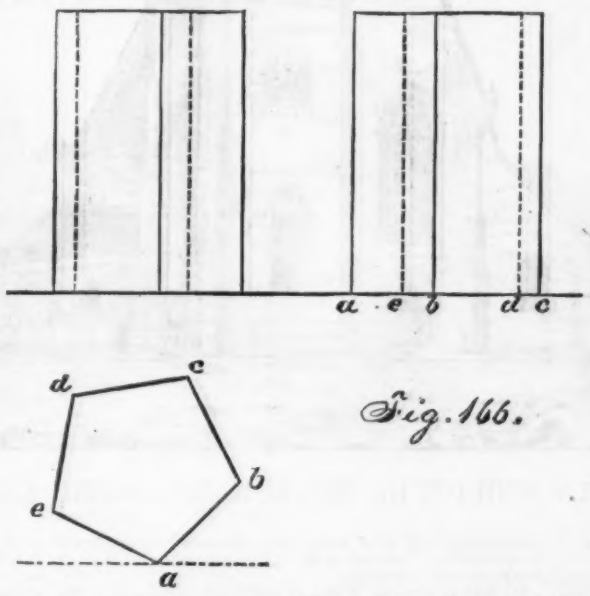


Fig. 166.

In regard to the hatching, or sectioning, it is worth while to repeat what has been said before—that is, that the lines with which it is done should be finer if any thing than the outlines, and the tone should be light. Judgment tempered by experience is the only sure guide to a proper selection in this matter, but we may say that the lines should be only a *little* finer than the outlines,—just enough to show a difference,—and that the spaces should in general be of a breadth several times as great as the thickness of the lines. Beginners are very apt to imagine that extremely close sectioning is a mark of skill; and if regularly done, so as to produce the effect of an even tint, it is so. But it is also a proof of bad judgment; for if the effect of a tint be given when seen at the distance at which one would ordinarily hold the drawing from the eye in reading it, the sectioned parts will be unduly prominent, and crush the outlines, unless the lines of the sectioning are excessively fine. In either case, except on very small surfaces, the effect is bad, and the waste of time is simply outrageous.

In Fig. 160 is shown a piece which is hexagonal for a part of its length, the rest being cylindrical, through which a round hole runs from end to end. The outlines of this hole, *a* and *b*, are actually invisible in the front view, which is not a sectional but an external one, and are there consequently drawn in dotted lines. For a like reason the circle in the top view in Fig. 161 is dotted, the figure representing a piece of a cylindrical bolt with a square head. And though it may be superfluous, it can at least do no harm to say that this is the customary manner of indicating lines which are concealed, either by other parts of the body to which they belong or by the intervention of some other body. Care should be taken to make them very regular and the dotting close, as has before been remarked in regard to all dotted lines; but the line should be as thick as any other outline. In reference to this, too, beginners are very apt to go to extremes, and make the dotted lines too feeble by excessive fineness.

Fig. 162 is a drawing of a cylinder having a circular flange at the top, and a square one at the bottom. Both the views being outside ones, the outlines of the cylindrical bore in the front view and the outside of the shell in the top view are dotted; and in the former the student will note the effect of the uniform shadow line on the lower flange, and the tapered one on the upper, as indicating, even by an inspection of that view, the difference in the forms of the two flanges.

The vertical wall of the cylinder, also, does not form a sharp square corner at its junction with either flange, but what is technically called a *fillet* is introduced, which is indicated by the small quarter-circles, tangent to the vertical outlines of the cylinder walls and the horizontal ones of the flanges. Thus the cylindrical portion really is terminated by parts having the shape of a trumpet-mouth. What we wish to call attention to is the circumstance that the junction of this swell and the vertical cylinder is indicated by drawing fine lines, *a b* and *c d*; and in making mechanical drawings for working purposes this should always be done. The student will no doubt meet, as we have met, many strait-laced devotees to precision, who will say that because the two surfaces, the trumpet-mouth and the cylinder, are tangent to each other along this line, the line itself is imaginary, and ought not to be represented. We admit that it is an imaginary line, and that it ought to be drawn as finely as possible; but we insist upon what we have already said, that the first object of a working drawing is to show what is to be made and how to make it, and on this ground, if no other, the drawing in of these "fillet lines" is defensible, as they call attention not only to the existence but to the size of the fillet in a more emphatic way than can be done otherwise.

And more than that, whether it is right or wrong, there is no denying the fact that their introduction is pleasing to the eye, and adds a finish to the drawing which without them is wholly lacking, as the student may very easily satisfy himself by experiment.

In fact, it is very easy by stickling for absolute precision to find fault with a great many things, as we shall take occasion to show, which aid in making a drawing clear and satisfactory, without in the least impairing its practical accuracy. For instance, an extension of the argument above quoted would lead to the exclusion of centre lines as being imaginary. Another ridiculous canon of these extremists is violated in Fig. 163, as it always ought to be. The figure represents a pulley with a piece of its shaft, the body of the pulley being in the form of a disk with a flange and central hub. This form is of course indicated to the best advantage by making the side view in section, as we have accordingly done. But we have shown the shaft in full; just as if we had split the pulley first, and then laid the shaft in the bore. "Now," says he of fierce precision, "that drawing is not correct: your side view is a section by a plane passing through the axis, and therefore cutting the shaft in two as well as the pulley." Were the shaft and the pulley all in one piece, that would have some weight. As it is not so, the explanation given above is sufficient. If others in carving a ham choose to cut through the bone at every slice, well and good, but we can not endorse the practice.

Now to return to the matter of projections. Again making use of the illustration employed in the preceding lesson, and supposing the object to be within the show-case, we observe that in going around from the front to the right-hand side, we turn through an angle of 90° ; or, using the geographical comparison, we look toward the west instead of toward the north. The effect, in so far as the relative position of the object and the observer is concerned, is the same as though he had, after drawing the front elevation, turned the object itself through an angle of 90° without changing his own position. This may in fact be done, in the study of this subject with the aid of a model ; it is just as well as to leave the model stationary, and change our own position. The turning now spoken of is around a vertical axis ; the height of every point remains unchanged, and it will appear, on a second's thought, that the appearance of the object as seen from above will be the same as before. If we lay a book flat on the table, it presents the same appearance to the eye looking down upon it, no matter how we turn it round, and it is just as thick in one position as in any other.

From these two considerations it is not difficult to deduce a method of constructing the projections of a body when thus turned around a vertical axis through any angle from its original position, if we have given the projections in that original position. To illustrate the process we take the most simple of bodies, the rectangular prism, like that shown in Fig 144. We repeat this in Fig. 164, in order to have the whole operation shown at a glance, and the steps and the reasoning clear ; but we have placed under the view from the right a repetition of the top view, by which is illustrated what was said above, that the side view might be made by turning the object through an angle of 90°. Now let us suppose that we turn it through an angle of 30° only ; in this case the top view will appear as in Fig. 165, the front and back making angles of 30° with the horizontal—that is to say, we copy the top view in Fig. 164 in a new position. This changes the distances measured from right to left ; but in constructing the front view, each point is to be perpendicularly over its new position in the top view, and as all the heights are the same as in Fig. 164, we have only to transfer them horizontally from that figure, and thus our new elevation is completed. In the original position, *b* was directly behind *a*, and *c* behind *d*, so that in the front view only one face of the block was visible. In the new position, *c* and *b* are farther to the right than *a* and *d*, and two faces are seen, but they do not appear in their true size.

The side elevation is now constructed from the two views already made, in the manner previously explained. Looking in the direction of the arrow, *a* is on the extreme left, *c* on the extreme right, *b* appears between them, being the point nearest the observer when looking from the right, and *d* would be seen farther to the right, if it could be seen at all, as it is obscured by the body, it is shown in the side elevation in a dotted line, as *c* is for a like reason in the front view.

The effect of changing the position of the top view, as the first step in the construction of the new drawing, is the same as though we had placed the front plate of our imaginary show-case at an angle with instead of parallel to the front face of the block, and looked perpendicularly against it. This is indicated in the top view in Fig. 164, in which *e f* represents the plate, making an angle of 30° with *a d ;* we have also let fall perpendiculars on *e f* from the points *b*, *c*, *d* (*a* in this case lies in the plate on which the projection is made), and it will be seen by measuring that the distances between the points thus determined on *e f* are the same as those between *a'*, *b'*, *c'*, *d'*, in the front elevation of Fig. 165.

Now it is to be understood that we selected the angle 30° as that through which the object was to be turned merely for convenience ; and we might as well have turned the object to the left as to the right. It does not matter what the new position of the top view is which is selected, as in this case, for the purpose of illustration, or which may be selected by the student for practice ; in making drawings for actual use in construction, this angle may be determined by the conditions of the problem, and in fact always is so ; but the mode of operation is what we wish to explain, and one angle is as good as another for this purpose. But we recommend the student to vary this in his practice—to take different angles, to make his views sometimes from the right side and at others from the left—to do any thing, in short, except to copy, in any case where principles and reasons are involved. We only hope that this will be superfluous and even exasperating advice to every one of our readers ; but we have seen so many who after one illustration of this kind were very sure that the art of drawing consisted in twisting their model through an angle of 30°, that we think it best to provide against accidents of that sort.

In Fig. 166 we give a drawing of a pentagonal prism, supposed already to have undergone this process, or, what is the same thing, being placed originally so that neither of its faces in the front elevation is parallel to the paper. This is readily constructed at once by drawing the top view first, and locating the angles of the pentagon to suit the fancy. Assuming the height, the front elevation is then made, and the side view built up from the other two, in the manner with which we suppose the student to be by this time so well acquainted as to relieve us from the necessity of saying any thing further in explanation.

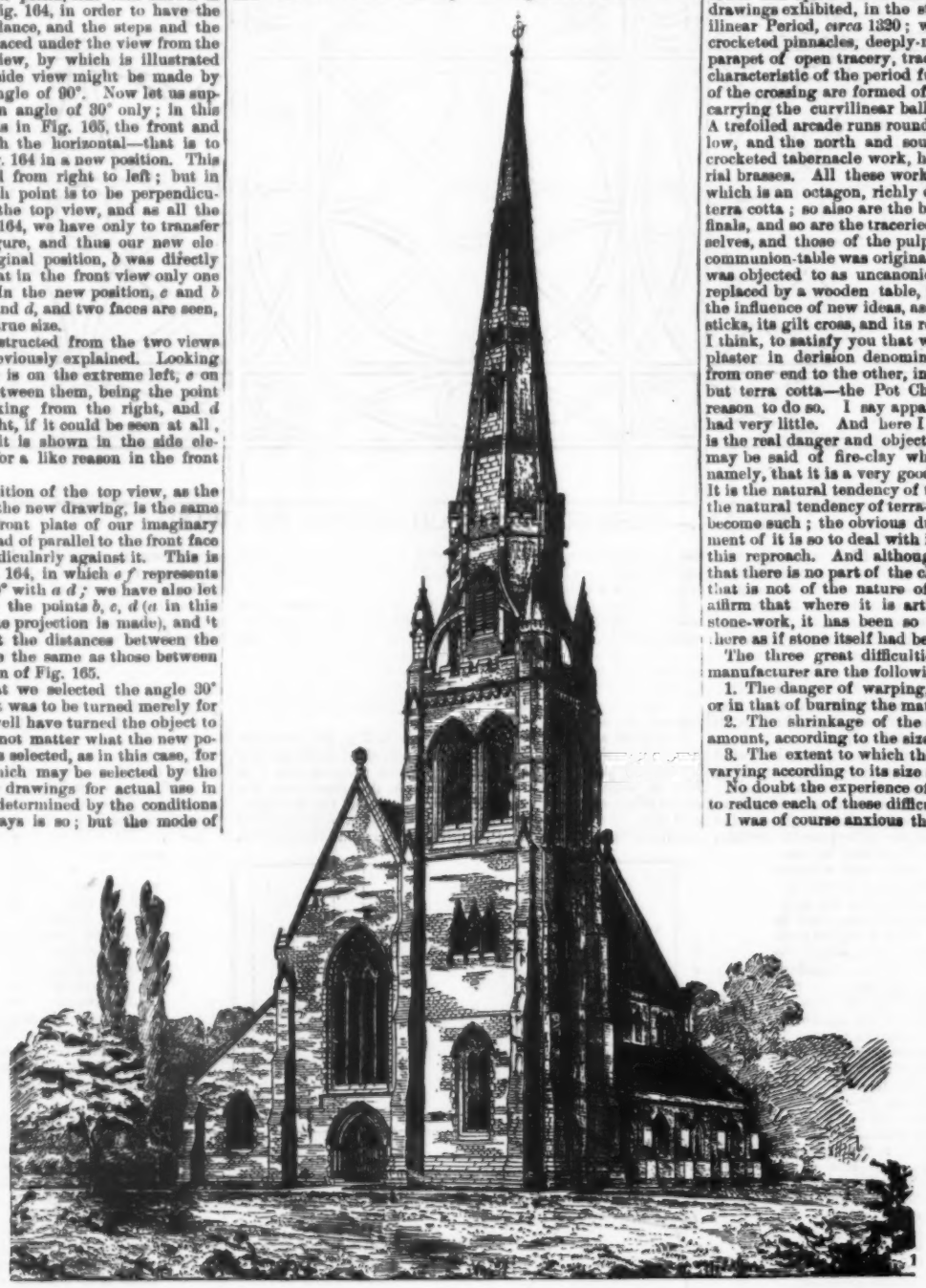
For further practice, the student may take any of the objects shown in Figs. 146, 147, 148, 150, and 151 ; and he is advised to practise by drawing these in various positions, with different proportions, and in different orders of arrangement as above explained, until he has thoroughly mastered the principles, and is able to make the constructions unaided by reference to instructions or illustrations.

We conclude by giving an exercise for practice in line work only, the design, Fig. 167, being that of an iron railing for a balcony. Probably it will explain itself ; at any rate, we think it unnecessary to say more than that the centres of the circular arcs *a a* are the corners of the squares forming the panels of the framing, and that the radii of the circles *b b* are the same as those of *c c*, their centres being of course on the prolongations of the centre lines through the centres of the squares.

TERRA COTTA ADAPTED TO MODERN CHURCH WORK.

By EDMUND SHARPE, M.A.

IN giving the results of my experience of the treatment and use of burnt fire-clay—an experience which is of very early as well as of very recent date—and my opinion of its suitability for church work of the present day, I shall do this as shortly as possible.



PLATT CHURCH, A TERRA-COTTA STRUCTURE NEAR MANCHESTER, ENG.—BY EDMUND SHARPE, M.A.

My first experience of the use of terra cotta was in the church of Lever-bridge, near Bolton-le-Moors, designed by me in 1841, and my latest experience has been in the construction of the church at Scotforth, near Lancaster, designed by me in 1874, and finished in the beginning of the present year. The church of Platt, near Manchester, was carried out soon after that of Lever-bridge, and consecrated in 1846. Of other works in which I have employed the same material, it appears to me unnecessary to give the details.

Lever-bridge Church was constructed out of the fire-clay deposits occurring in the colliery of the late John Fletcher, Esq., of the Hollins, near Bolton-le-Moors. These deposits, in the form of small hard nodules, are generally found in the coal measures of that district. On exposure to the air they disintegrate and fall to pieces, and are then ground to powder under heavy rollers, formed into paste-like clay, and made into refractory fire-bricks for furnaces, coke-ovens, and similar purposes : this, at all events, was the only use to which this material had, up to that time, been applied. Mr. Fletcher, who was the chief promoter and the largest subscriber to the church at Lever-bridge, conceived the idea of building it entirely of this material, and I undertook to prepare the designs for it, and to superintend its construction.

The experiment was a bold, not to say a hazardous, one, and its realization was an extremely arduous affair. Kilns had to be built and other necessary premises to be constructed ; experienced workmen had to be engaged, and, above all, a competent and able modeller to be secured. It was, in fact, the creation of a new enterprise. Suffice it to say that, thanks to the indomitable perseverence of Mr. Fletcher, all was brought to a successful issue. The church was in due course commenced, completed, and consecrated. It was, I believe, the first work of the kind in modern times in which terra cotta had been used on so large a scale ; for, with the exception of the foundations and the rubble-work between the outer and inner faces of the walls, neither stone nor bricks were used, and with exception of that under the slates there is not a square foot of plaster in the building, the face of the walls inside and outside being formed of fire-clay blocks, in 5-inch courses, well bonded into the rubble-work, and built like an ordinary ashlar wall.

It is a small cruciform church with an apteral or aisle-less nave, and a short chancel, north and south transepts, and west tower and spire. It is designed, as will be seen from the drawings exhibited, in the style of the early part of the Curvilinear Period, *circa* 1320 ; with a spire of open tracery-work, crocketed pinnacles, deeply-moulded door and window jambs, parapet of open tracery, traceried windows, all other details characteristic of the period fully carried out. The four arches of the crossing are formed of continuous arches of two orders, carrying the curvilinear ball-flower in one of their hollows. A trefoiled arcade runs round the three sides of the chancel below, and the north and south walls above carry a series of crocketed tabernacle work, having niches intended for memorial brasses. All these works are in terra cotta. The font, which is an octagon, richly diapered and panelled, is also in terra cotta ; so also are the bench-ends, with their panels and finals, and so are the traceried panels of the seat-backs themselves, and those of the pulpit and organ-case. Indeed, the communion-table was originally a terra-cotta structure, but it was objected to as uncanonical, and ultimately removed, and replaced by a wooden table, which, however, has now, under the influence of new ideas, assumed its super-altar, its candlesticks, its gilt cross, and its reredos. I have told you enough, I think, to satisfy you that when the upholders of stone and plaster in derision denominated this small church—which, from one end to the other, inside and outside, shows nothing but terra cotta—the Pot Church, they had apparently some reason to do so. I say apparently, for in point of fact they had very little. And here I may tell you at the outset what is the real danger and objection to the use of terra cotta. It may be said of fire-clay what has been said of fire itself—namely, that it is a very good servant, but a very bad master. It is the natural tendency of terra cotta to become pottery, and the natural tendency of terra-cotta manufacturers to cause it to become such ; the obvious duty of the architect in his treatment of it is so to deal with it as to preclude the possibility of this reproach. And although I will not go so far as to say that there is no part of the church where terra cotta is used that is not of the nature of stone-work, yet I will at least affirm that where it is artificially used, so as to resemble stone-work, it has been so treated that the work is as solid there as if stone itself had been used.

The three great difficulties which beset the terra cotta manufacturer are the following :

1. The danger of warping, either in the process of drying or in that of burning the material.
2. The shrinkage of the material, varying as it does in amount, according to the size and form of the piece.
3. The extent to which the piece has to be fired or burnt, varying according to its size and form.

No doubt the experience of the last 30 years has done much to reduce each of these difficulties to a minimum quantity.

I was of course anxious that, wherever it was possible, the terra cotta should be solid throughout ; it was, however, found impossible in all cases to realize this. In the door and window jambs, arches, and sills, in the buttress set-offs, in the pinnacles, and in the base course, the warping of the moulded lines, and the difficulty of thoroughly burning solid pieces of so great a size, obliged us to abandon this attempt, and to hollow out, to a certain extent, the back of the work, this hollow being filled in with concrete in such a manner as to render the whole perfectly solid.

The most remarkable feature of the church, no doubt, is its traceried spire, which is built of solid terra cotta from top to bottom, dowelled together, not with iron, which is much less durable, or with copper, which is much more costly, but with terra-cotta dowels, which are imperishable.

The six traceried windows of the tower, transepts, and east end, and the two-light windows of the nave, are treated in the same way.

The church contains sitting accommodation for 350 persons, and cost—as it now stands—£2600. What it would cost in stone I never took the trouble to calculate, but the spire alone would, I should think, cost as much as the whole church has

Looked at as a piece of ordinary mason's work, it would be difficult to find a fault with it; nor would a stranger, seeing it for the first time, deem it, either from the appearance of its color or its workmanship, to be any thing else. Its primitive color when first built was a ruddy buff, which is now considerably deepened by an exposure of 30 years to the smoky atmosphere of Bolton-le-Moors.

PLATT CHURCH.

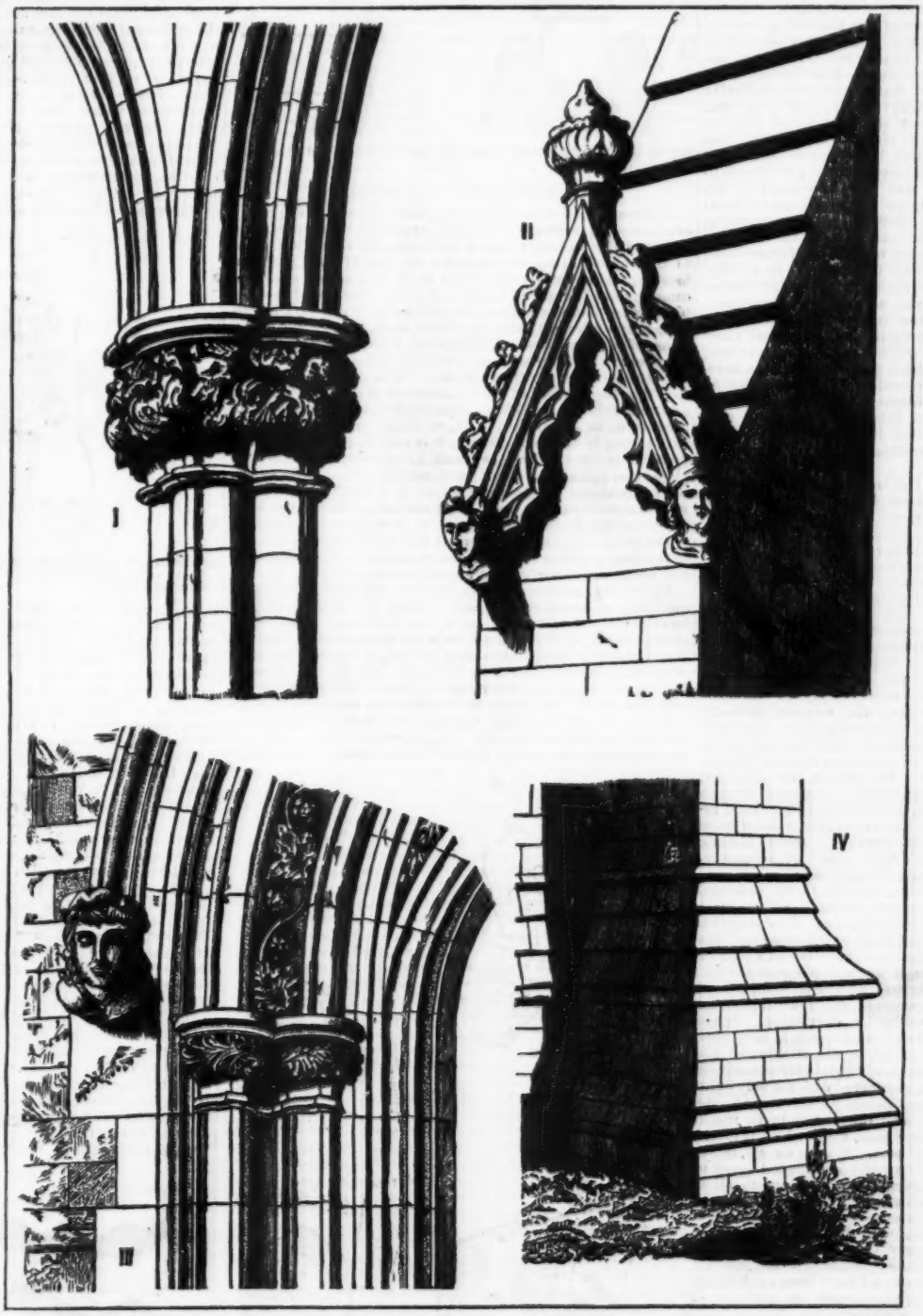
This design, it must be explained, was made in the year 1844—that is to say, thirty-two years ago—and therefore very early in the Gothic revival, of which we now hear so much.

The experience gained in the construction of the former church lessened considerably our difficulties in dealing with the second. Their designs differ, however, considerably in character: the later church has less ornamentation, but it has clustered piers, floriated pier capitals, and moulded pier arches, of which the accompanying diagram gives an example. It has a large five light east window, of flowing tracery, a diapered parapet to the aisle and clerestory walls, and a tower and spire 170 feet high. The whole of the exterior is of terra cotta, the coursed walling being of 5-inch blocks as at Leverbridge. The backing of the walls, however, is of brickwork, and the interior surface is plastered throughout. The spire springs from an octagonal lantern of particularly light work, which has suffered much from a cause that will be presently noticed. Altogether, I think I am right in holding this tower and spire, considering the time at which, and the material of which, it is constructed, to be a very remarkable work, and deserving of more care than it has of late received from those who have, under the Lord Chancellor, the charge of it.

The whole work has been treated, as will be seen, as a work in masonry, and I believe very few of those who live in the populous neighborhood in which it stands are aware that it is not so.

All that has been said before in regard to what is solid and what is hollow in Leverbridge Church applies equally to this church. Platt Church contains 650 sittings, and cost, exclusive of stained glass, about £4000.

Of all materials, natural or manufactured, there are few that are so durable as terra cotta; the examples of it, some thousands of years old, that have turned up in Egypt, Assyria, and elsewhere, prove this beyond a doubt. But it is so on one condition alone—namely, that it be, in the language of the trade, thoroughly "fired." We were fully aware of this condition when we commenced the work for Lever-bridge; but we were hardly aware, at first, of the much larger proportionate increase of time in burning to be given to the larger pieces, in order to ensure their complete induration. The defect only made itself apparent after the material was built into the work, and a considerable number of pieces have accordingly had to be taken out and replaced. This has by degrees been done, and the church is now in a sound condition throughout. At Platt Church, on the other hand, where, in consequence of these failures, the whole work was much more thoroughly burned, a much more satisfactory result was obtained. I have recently inspected the church, and, with the exception of certain defects in the spire and upper part of the tower, due to other causes, the whole of the church, nave, aisles, and choir, are in excellent condition, and as sound apparently as the day they were built—a result which is entirely due to the greater extent to which the material was fired.



PLATT CHURCH, A TERRA-COTTA STRUCTURE NEAR MANCHESTER, ENG.

This necessity for long and hard burning is diminished in proportion as you diminish the body of the clay, by hollowing out the back of the piece, and render it to that extent less solid; but here we fall upon another evil almost greater than the first; for it is pre-eminently unsatisfactory to reduce the ornamental part or show-side, so to speak, of the block to the condition of a shell, while honest stone or concrete does duty at the back as the real masonry of the building. I need scarcely say that this is not the manner in which the terra cotta used in these two churches has been treated; still there must always be the tendency on the part of the manufacturer to ensure the durability of his material by lessening the amount of its solidity—a result which goes far to prove that to employ this material in these large masses is a use of it which is in a direction and of a nature opposed to its natural capabilities.

It was this consideration which determined me, should I ever have occasion to use terra cotta in church work again, so to use it as to ensure the complete burning of the whole work with a moderate amount of firing; or in other words, to use only small pieces throughout the whole building, and to limit them, in fact, to the following dimensions—namely, for the ordinary walling blocks, 9 inches by 4½ inches by 4 inches, giving a cubical content of 162 inches, and for the largest pieces of ornamental work a maximum of 400 cubic inches—and thus, instead of obliging the terra cotta to suit the design, so to prepare the design as to suit the terra cotta.

Now it is obvious that this limitation in the size of the blocks to be used is inconsistent with Gothic work of the kind that was prevalent in this country in the thirteenth and subsequent centuries. Indeed, the massive effects that we see realized in Norman work were produced by stones much smaller in size than those which were used in certain situations in Gothic work.—*The Building News.*

LIGHTNING IN WALES.

DURING the month of May there was some severe lightning in Wales. In one case the gutta-percha of the "leading-in" wires at Aberkenfig was melted, the gas ignited, and a portion of the station burnt. In an adjoining field the same storm killed a horse, a cow, and some thirty turkeys. At Llanilar the chimney of a farm-house was struck, and split nearly in two. The force then divided, one portion taking its course down the chimney, the other over the roof and down an iron pipe employed to carry off the rain-water. Following the course of the latter from the chimney to the eaves of the roof, a track some 4 ft. in width was cleared of the slates composing the roof. On passing a joint in the rain-water pipe the cast-iron was melted in two places. At that end of the pipe which was buried in the soil, the ground was torn up for about three yards, where a dry well intervened, and which would seem to have produced a further division of the force, one portion passing into the yard, tearing up the soil for another five yards; the other taking the course of a wire fence for some 15 yards, down the corner-post of which it passed to the earth, which it here, as in other instances, displaced.

The portion which passed down the chimney tore off a wooden mantelpiece, which it broke into three pieces, hurling a portion with such force across the room, in the direction of the door, that it became as firmly nailed to the floor by the nails which it carried with it, and by which it had been originally fixed, as if a hammer had been used to do so. Here again the charge would seem to have taken two courses, one portion passing to the left, shattering the stones in its way; the other taking the wall to the right, which it passed through to a room having a damp floor, disturbing the flag flooring, and through another stone wall into the farm-yard, where all trace of it happily ceased.

In most of the upper rooms of the house the plaster was in places torn from the ceilings. The family were at the time seated in the kitchen around the fire, and escaped uninjured. The room in which the mantelpiece was displaced had not been used for a long time, and was probably in a damper condition than the other portion of the house. The only metallic conductor about the house was that afforded by the rain-water pipe—a very imperfect one, as will be seen from the fact that the resistance at the point was such as to cause the metal to be fused. The soil, which is red and a little sandy, presents no appearance of fusion where the charge apparently became lost in it.

The portion of the roof from which the slates were stripped is towards the front of the house, and some fifty yards distant from this point is a spring of water. For more than the first half of this distance, bits of the slate torn from the roof were strewn in almost a direct line between the damaged roof and the spring of water; whilst the farmer states he picked up bits of glass close to the spring, which he is of opinion must have been carried there from two panes of glass which had been forced out of the upper-room window. The house stands on a hill, but some half-mile from it is one of a much greater height.

It is certain that had this house been provided with an efficient lightning protector, it would have escaped the damage here narrated. As it is, it stands as one more instance of the general need of lightning protectors for all buildings occupying a more elevated position than other objects within their immediate neighborhood. It is not the first railway station, nor the first farm-house, which has been set on fire by lightning; yet if an examination were made, it would be found that not one public building out of a thousand is provided with so cheap and simple a protection, whilst as regards private residences its want is still more felt. Lightning protectors should form one of the items in every specification for new buildings.—*Engineering.*

A BEAUTIFUL ORNAMENT.

HAVING had occasion a short time ago to be in the city of Cleveland, Ohio, I was much struck with the manner in which I saw several hearths in sitting-rooms decorated. A box was made of a size suitable for resting on the hearth, without projecting too far into the room, and in this were planted some of the commonest native ferns, such as the strong-growing *Asplenium*s, *Osmundas*, *Aspidium*s, *Struthropteris*, and the beautiful and graceful Maidenhair (*Adiantum pedatum*), which grows luxuriantly in the moist, rich woods along the banks of Lake Erie, and other places throughout the State. Planted rather closely, and kept well watered, any one may possess such an ornament during the summer months. It is strange how anxious we are to get a plant from a foreign country, even though it may not possess half the beauty which some of those growing in our woods have. Still we will pass them, and nurse, it may be, one far inferior in flower and foliage, and a great deal more difficult to grow, just because it is an exotic.

There are hundreds of different flowers in the United States well worth cultivation in every garden, many of them possessing a beauty equal to some of the best exotics we can introduce, and which, if properly cared for, would, with their increasing vigor and abundance of flower, amply repay any extra labor given them.—*Country Gentleman.*

EFFECT OF COLD UPON MILK AND ITS PRODUCTS.

THE *Annales de Chimie et de Physique* contains a paper giving an account of some experiments made by M. Eugene Tisserand, Inspector-General of Agriculture, to determine the influence of cold upon milk and substances derived from it. From these experiments he has drawn some general conclusions which have an important bearing upon the methods employed for the conversion of milk into butter and cheese. Neither are they without interest with respect to the composition, at different times of the year, of milk standing in pans, from which portions are at intervals ladled off for the purpose of sale.

Upon the freshly-drawn milk of a cow being submitted for twenty-four or thirty-six hours to different temperatures between zero and 36° C., M. Tisserand observed that whilst the rising of the cream was more rapid in proportion as the temperature approached zero, the volume of cream and yield of butter were larger and of better quality from milk that had been exposed to a low temperature than from milk which had not.

MANUFACTURE AND WORKING OF STEEL.

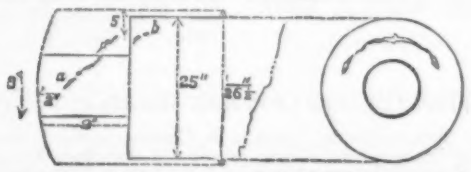
By D. CHERNOFF, Assistant Manager of the Abouchoff Cast Steel Works, near St. Petersburg. Translated by W. Anderson, M. Inst. C.E.

(Continued from page 574.)

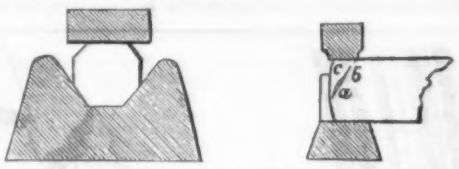
FROM what has been said above, you must have perceived that the whole point lies in the structure of the steel, and that, for successful forging, the heated ingot, after it is taken out of the furnace, must be forged as quickly as possible, so as to leave no spot untouched by the hammer, no spot in which the steel might crystallize quietly, because, as I have said, the heated piece of steel must be considered in an analogous condition to a saturated solution of a strongly crystallizing salt, which, the moment it is allowed to cool quietly, develops large crystals. I repeat that this has reference to temperatures higher than *b*.

To show you how great is the tendency to crystallization in steel heated up to a high temperature, and allowed to cool quietly, even for a short time, I have brought some specimens by which you can judge of this tendency. The larger specimen was obtained under the following circumstances: An ingot of soft steel prepared for forging was allowed to remain in the furnace for half an hour after it had been heated to a bright orange heat, because the hammer was occupied by another forging. But, in order not to overheat the ingot, the smith reduced the temperature of the furnace, and gradually let down that of the work to a bright red. If you will now call to mind what I have said about the tendency of steel to crystallize in cooling between the temperatures *c* and *b*, you will readily believe that during this half hour the ingot had time to change its internal structure from the amorphous to the crystalline, a change which was greatly assisted by the extreme softening it had undergone at the higher temperature, which presented favorable conditions for the movement of the particles within the mass. As soon as the hammer was at liberty, the ingot was taken out of the furnace, and placed on the anvil; with the very first blow on its middle, the end of the ingot tumbled off from the effects of the concussion; the form of the fracture you can see on the first specimen before you. The remaining samples are taken from other ingots under similar circumstances, and they all show how strongly the crystals have developed themselves; and, moreover, each crystal seems to have formed itself in an independent manner, with so little cohesion to the neighboring crystals that one shock was sufficient to separate them, and allow the overhanging piece to detach itself by its own weight. The specimens show that fracture has taken place only along the surfaces of the crystals, and nowhere through the body of them.

It might be concluded from the incident above described that the ingot was completely spoiled, and could not be forged again. But such a conclusion would be quite erroneous. It is true that the higher the temperature of the steel, the more susceptible is it to the action of the furnace gases, and the quicker it changes its chemical condition, so that if kept to a high temperature in the furnace it will gradually lose its carbon and be slowly converted into iron, burning. The example I have cited, however, is only a case of overheating; and in order to know how to correct the mistake made we must turn to the conditions of crystallization. Let us, again, take the beaker of melted alum. Suppose the melting point to be t_0, and that the solution was further heated up to t_1 under which operation it would continue liquid. Let the temperature fall gradually, keeping the solution perfectly quiet, then we shall find that at some temperature t between t and t_1 the salt will begin to crystallize; but it is only necessary to shake up the solution to make the crystals dissolve again at the same temperature t. We shall notice, also, that there is scarcely any cohesion between the separate crystals so formed, and if we do not wish to disturb their mutual relations, we shall have to allow the crystallizing solution to cool below the temperature t_0, and then by a second heating up to t_0 we should again receive a fluid mass. The same result would be obtained by a simple single increase of temperature; the difference lies in this, that the liquid produced from the destruction of the incipient crystals in the three cases stated has three distinct temperatures. Applying this reasoning to steel, it is easy to see that, in the case cited, the temperature of the ingot should have been raised again before forging, so as to impart to it an amorphous structure; it should then have been quickly and unceasingly forged all over its extent while the temperature was lowering somewhat, and the tendency to crystallization decreasing. Or the particles that had commenced to crystallize might have been brought into a motion corresponding to the shaking of the beaker, but very carefully, so that the crystals formed should not fall to pieces; in other words, hammered with the very lightest blows; and the temperature being higher than *b*, the crystals would have run into each other, the ingot would have assumed the amorphous condition, after which it might have been worked like a piece of wax. It is, of course, better under such circumstances to allow the overheated ingot to cool quietly, then to heat it again, taking care not to allow the temperature to rise too high and give the mass an opportunity of again changing the restored amorphous condition to a crystallized one; the forging will then not require any special precautions, and the ingot will not tumble to pieces. I now present you with one of many instances of the spoiling of large steel ingots from the causes I have been explaining, and proceeding from a thorough ignorance, on our part, of the material with which we are working.



On cutting off the end of a shaft of 25 in. diameter, the shake *a b* was met with in the position indicated in the sketch. The dotted lines show the form of the forging before the neck was turned. The walls of the cavity were lined with large, well developed crystals, the size of some of which—as you may see by the specimen before you—reached half an inch, and between the large crystals were interposed smaller ones about one tenth of an inch diameter; the crystals projected only half their height into the cavity, and on breaking the sample at right angles to the crystalline surface, the prolongation of the crystals into the mass of steel could not be traced; the fracture, though crystalline, was of a totally different nature from that forming the surface of the cavity, and similar to that of the mass of the ingot in the same neighborhood. The surface of the wall of the cavity had a clear unoxidized metallic appearance, with a silvery lustre, as you see by the specimen. The ingot out of which this shaft was forged was overheated in the manner I have described, and taken out of the furnace when the crystals had already begun to form. At the first blows of the hammer on its end the part *c* which received the full force of the blow was separated from the mass on account of the want of cohesion caused by the crystallization, and formed the internal inclined plane *a b*; and as the forging proceeded, the outer layers, being more acted on by the blows, were more extended, and the cavity considerably increased. The fact that on striking the end of an ingot the force of the blow is taken up by the wedge-shaped piece *c* may be easily demonstrated to the eye, because in those places where swelling, compression, or tension follows the blows of a hammer, a dark shade is soon produced by the partial detachment of thin plates of scale. The same result will be arrived at by an analytical investigation of the effect of a blow on *c*. The appearance of the crystallized surface of the specimen is, as you see, completely analogous to that of every other specimen of overheated steel; the difference lies only in this, that the surface is not oxidized because the



air could not penetrate into the cavity while the shaft was in a heated state.

STEEL CRYSTALLIZED BY OVERHEATING.

It is worthy of remark that if a piece of steel be so greatly overheated as to assume a strongly crystalline structure, and become liable to destruction at the least shock, and is allowed to cool quietly, then the separate crystals, if they have not been separated by external forces while in a heated state, become so joined or grown together that the fracture of the cold piece takes place, not along the surfaces of the separate crystals, but indifferently through their mass, though the junctions of the fractures of individual crystals generally take place along their planes of adhesion, owing to which such fracture is always very sparkling. From this it is evident that the close contact of two surfaces of metals of the same nature heated to a higher temperature than *b* is sufficient to produce union. This is, in fact, welding; and if, in welding, hammering is always necessary, it is only because, in the first place, it is very difficult, without hammering, to press two pieces one against the other; and, secondly, that it is otherwise difficult to free the surfaces to be welded from the slag which alone protects them from oxidation during the heat. Of course the more homogeneous or analogous the structure of the two pieces, the more perfect will be the union; but one of the first conditions is that there should be the fullest contact between the unoxidized metallic surfaces.

Up to the present we have been discussing the forging of steel only at temperatures higher than the point *b*, and we have stated that the aim of the forge-master must be to change the form of his ingot in such manner as to keep all its particles in constant motion, and so hinder the formation of crystals, which materially lower the tenacity of the steel. Let us now see what circumstances arise in forging below the temperature *b*. The fracture of a piece of cast steel presents a rough surface consisting of groups, as it were, of crystalline *débris*—so called grains—piled one on another, and generally of a very irregular form. Under the microscope it is easy to

FIG. 2

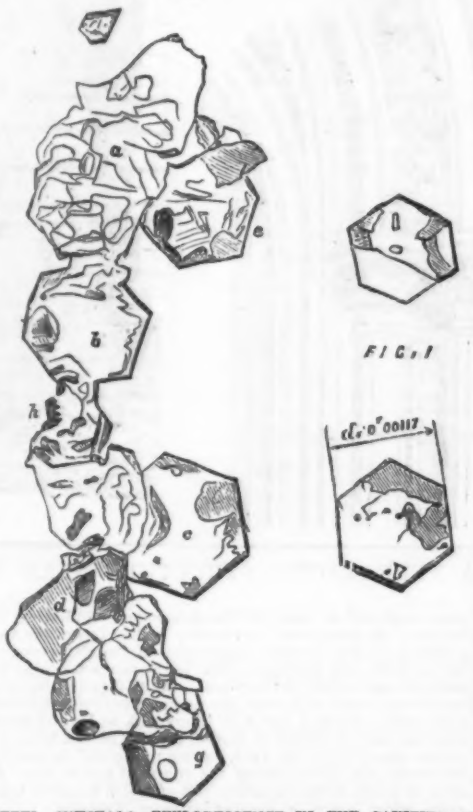


FIG. 1

STEEL CRYSTALS.—EFFLORESCENCE IN THE CAVITIES OF TOOL STEEL.

Fig. 1.—Crystals taken from the sides of a cavity in steel ingot formed by contraction—magnified 550 times.

Fig. 2.—Groups of crystals taken from the sides of a cavity formed by contraction in a cast-steel ingot—magnified 550 times.

see considerable interstices between the groups of grains, and on more minute examination, spaces may be observed between the grains themselves, which form with each other various interlacings and combinations. In a word, steel, under the microscope, has a more or less porous structure, at first sight; destructive of any belief in the tenacity ascribed to it. Time will not permit me to enter into details relating to the appearance, size, and arrangement of the grains; it answers my purpose simply to direct attention to the fact that among the grains of steel there are numerous vacant spaces—pores. The question arises—what becomes of these pores when the steel, being heated up to the temperature *b*, acquires the amorphous condition? In all probability, during the rise of temperature from *a* to *b*, the expansion of each individual grain, formerly in itself a compact body, goes on incomparably faster than the increase of the external dimensions of the piece of steel, so that the period at which it assumes the amorphous condition coincides with the moment when the atoms composing the individual grains, moving away from each other under the influence of heat, fill up these spaces; it is, therefore, conceivable why steel becomes at this stage incompressible—why it is impossible to increase its density by hammering, no matter how heavy the blow may be.

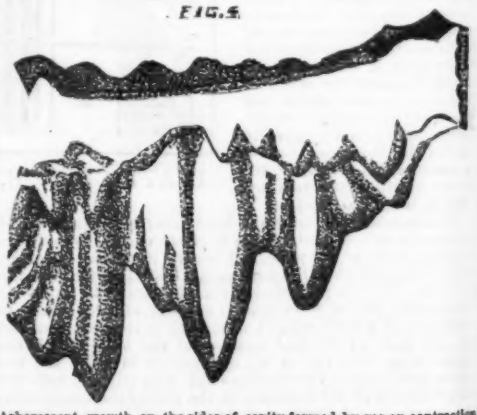
It is evident, from the above reasoning, that if we wish to increase the density of steel to approach its component grains to each other and so bring them to a more energetic cohesion, we must do so when not opposed by the force of heat, that is only at temperatures below the point *b*. Thus, forging at temperatures below the amorphous condition has the important advantages we are in the habit of ascribing to it. We never forge large ingots below the temperature of amorphous structure, and guns never were and never are forged below that point, because for gun steel it lies, as I have already stated, at a dull red heat—that is, within limits below which, with the mechanical means at our disposal, we can produce no effect on large steel masses. It would be necessary to forge small ingots under our largest hammers, and what an exhibition of inadequate mechanical appliances would be presented if a 4-pounder gun were forged under a 35-ton hammer! The practice now is to forge the 4-pounders under the 3-ton, and sometimes the

Appearance of a transparent substance that crystallizes in six-sided plates on the surface of cavities formed by contraction in steel ingots—magnified 165 times.

5-ton, hammer, while the 35-ton hammer is used for the 6-in., 8-in., and 9-in. guns, in which the diameter of the cast ingot reaches up to 40 in.; but if you picture to yourself such a large mass of steel heated to a non-sparkling red heat, you will perceive that the utmost efforts of the heaviest hammer will remain inoperative—it would be impossible to forge it. Forging is carried on at points below the amorphous condition, but it is only in very small pieces, and by those who have some knowledge of the influence of heat on steel.

If a cast ingot of any given structure is heated not higher than the point *b*, then in its heated state it will retain its structure. If it was crystalline, then in a heated state it would be composed of the same crystals, which, however, would be considerably softened. If the piece of steel be forged in this condition, then its crystals or grains, being driven against each other, will change their shapes, becoming elongated in one direction and contracted in another, and the increase of density becomes so considerable that I have found the specific gravity rise as high as eight, which I have never yet found in steel forged at temperatures higher than *b*. This comparatively cold forging communicates to the metal great clearness of ring, it is no longer so easily worked with the file, weak sulphuric acid produces hardly any effect on it, and so on. With regard to its absolute tensile strength, I regret very much that I have been unable to make any experiments; but there can be no doubt that it is very high. The fracture of such steel has a silky lustre, and under the microscope it is very difficult to trace the limits of the individual grains; they present the appearance of waxy little balls squeezed together under a powerful press. If you cut off and polish the surface of a piece of steel so treated, and then immerse it in weak sulphuric acid, after a time a pattern will form on the surface, which presents the appearance of an irregular interlacing of crooked lines, the size of the network

FIG. 3.

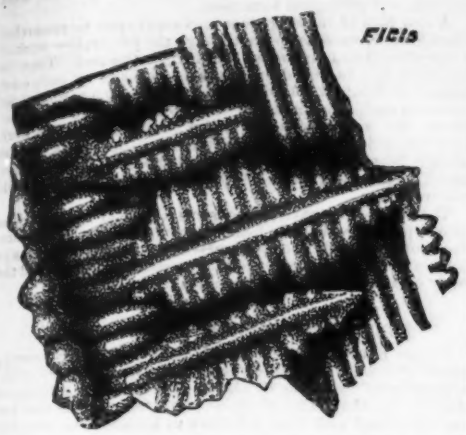


Arborescent growth on the sides of cavity formed by gas on contraction in cast-steel ingot—magnified 159 times.

depending on the original size of the crystals, the manner of forging, and so on. I have already stated that the tendency to crystallization, as well as the form of the crystals and their relative positions, depends on the purity of the steel, and the conditions under which the cast ingots are poured and cooled. In the higher qualities of boulat, the tracery developed by acid is of remarkable beauty and regularity.

The cause of the patterns appearing is the various groupings of the crystals during their formation. These crystals have not the same chemical composition; the lighter parts

of the tracery contain much more carbon than the darker parts—a fact which I have demonstrated—and consequently, simultaneously with the grouping of the crystals or grains, there is a segregation of like chemical compounds. If you heat the piece of steel thus marked—damascened—up to the temperature *b*, or a little higher, and allow it to cool again, you will no longer be able to obtain any pattern by the action of acids. From what has been already said, the cause of this must be quite plain, and I need not dwell on it any longer. In conclusion, I will show in what manner the properties of a cast-steel ingot may be best taken advantage of. With respect to forging at temperatures below the amorphous condition, we can only, as I have already stated, make the smallest guns under the largest hammers. We have at present no mechanism capable of dealing with large masses at low temperatures; but if it were possible, there can be no doubt that guns so forged would be of the very best quality, and their reception into the service would be facilitated by the appearance of the patterns brought out by weak acids, because of the close connection which exists between the quality and the appearance of the steel so treated.



Crystals on the surface of a contraction cavity in the heart of a 72-lb. cast-steel ingot—magnified 165 times.

Insoluble substance remaining after dissolving steel in nitric acid—magnified 155 times.

Two grains from the fracture of an ingot of cast steel 1-in. forged diameter of 0.027 in.—magnified 150 times.

HOW TO PRODUCE FINE-GRAINED STEEL.

To adapt ourselves to the means possessed by our steel-works, we must strive to obtain our material as much as possible of a fine-grained structure; and with this view it is necessary, as we have already seen, to heat the ingots to a high temperature, and to keep forging them until they cool down below the temperature *b*, because, by so doing, we shall be giving the work the required form, and at the same time prevent its structure becoming crystalline, but rather make it approach the amorphous condition. But if we examine the circumstances attending the practical application of this rule to the forging of ingots intended for heavy guns, we shall find that, in many cases, it will be impossible to carry it out, and a forging will be obtained the structure of which is far from uniform, and more likely to be coarse crystalline than fine-grained. We shall attain our object more easily, and with more certainty, if after having given the forging the desired shape, we alter its structure to the homogeneous amorphous condition by heating it, and then fix that condition by rapid cooling to a temperature lower than *b*. For this purpose it is of course necessary to surround the ingot, after heating, by some rapidly-cooling medium.

From what has been said above, it is evident that, with the same rate of cooling, we shall fix the amorphous condition of the steel with the greatest certainty when we exceed the temperature *b* as little as possible; and for that reason it is well to determine that temperature for each ingot beforehand. Having, therefore, heated the finished forging, or, better still, the rough turned and bored gun, to a temperature somewhat higher than *b*—a point which ought to be determined by the pyrometer—let it then be plunged as quickly as possible into the cooling medium, be it water, oil, or what not, and having reduced the temperature of the work to below the point *b*, allow it to finish cooling gradually, so as to prevent, as far as possible, internal strains due to sudden and unequal contraction.

SPECIMENS OF STEEL.

To show you what changes may be produced in the structure of steel by the operations described, I lay before you three specimens. They are all broken from the same piece of steel. The first specimen exhibits the coarsely crystalline, porous structure that characterized the ingot, notwithstanding that it was well worked under the 35-ton hammer. The second sample was heated to a little above a bright red non-sparkling heat, and then allowed to cool in the open air. Comparing the fractures of these two pieces, you perceive the structure is totally different, though offering one surface to the other proves by the fit that the two pieces were at one time united, and that neither piece has been touched by the hammer since they were broken asunder. The third fragment of the same piece was heated to a bright red heat, and then quickly plunged into water, and left till the temperature sank to a reddish-brown heat; it was then taken out and allowed to cool in the open air. The fracture shows that on the external surfaces, for a depth of 0.1 in. the amorphous condition has been completely preserved. In the centre of the piece the mean diameter of the grains, as measured by the microscope, is 0.0004 in., while the mean diameter in the first piece was 0.15 in., and in the second, 0.005 in. To this I may add that to break the first piece one blow of a hand-hammer—(7 sledge)—was sufficient, to break the second required five such blows, and the third piece had to be broken under a steam-hammer, because the strength of the smith was inadequate for the work.

A similar experiment was made with the tire of a railway wagon wheel. A piece of an ordinary tire was broken by a 5-ton hammer into three pieces. One of them was heated to a light red, and then thrown on the floor to cool in the open air to the ordinary temperature. It was then put under the 5-ton hammer, and required four heavy blows to break it, whereas the first piece broke under one blow of the same hammer. The third piece I heated to a bright red heat, plunged it quickly into water, and took it out again when cooled to a reddish-brown heat, and then found that it required five heavy blows of the 5-ton hammer to break it. Therefore I say, that in order to fix the amorphous condition, and thereby to increase the tenacity of steel, it is necessary to plunge it, after heating, into water. It may be cooled in oil, but, in the first place, this is expensive, and, in the next, numerous precautions have to be taken to prevent the oil catching fire. With respect to cooling in water, I must add that the conductivity of hot metal is very small, and that although the external visible parts soon show the desired fall of temperature, yet the central portions remain very much hotter; it, therefore, requires care, experience, and many precautions to avoid the too rapid cooling of the outer layers, and the consequent development of severe internal strains. Time will not permit me to treat this subject in greater detail. I can only state my opinion that not only should every gun be subjected to the treatment above described, but also every article made of steel, as, for examples, tires, axles, shafts, etc.*

It follows, from the principles laid down, that any steel article having, from constant work and concussion, lost its original strength—that is, assumed a crystalline structure, as happens to wagon axles, engine shafts, etc.—can, by the help of the process above described, be completely restored by having communicated to it, if not an amorphous structure, at least one so finely grained as to be nearly equal to it, and, at the same time, a compactness and tenacity it very likely did not possess when newly taken into service. I trust that you will now find it easy to understand the circumstances and facts which I brought under your notice at the commencement of this paper. I have heard with pleasure, from a friend just returned from England, that at the Woolwich Arsenal they have adopted the practice of heating their steel-gun linings, after forging and rough turning, and plunging them into oil; he was unable to give me any details of the operation, as he only noticed it in passing, but the object of the treatment was, he ascertained, to give the steel greater tenacity. It is possible that I may soon obtain information as to the reasoning which led to the adoption of this practice, and I shall be exceedingly pleased if I find it is based on theories similar to those I have had the honor of laying before you this day. With respect to the doctrines I have been advocating, I have been accused of being too bold in my conclusions, but I am prepared to take a still more decisive step, and to announce the opinion, resulting from my observations, that "future investigation into the question of forging steel will not deviate from the path into which we have this day directed it."

APPENDIX.

The following notes of microscopical observations have never yet been published. The drawings annexed were made under the microscope, with the assistance of Hartnack's camera lucida, in the years 1868 and 1869. Figs. 1, 2, and 3 are especially remarkable. They represent the efflorescence appearing in the cavities of hard tool-steel, melted in a crucible, and allowed to cool extremely slowly in its furnace. The ingot on cooling exhibited cavities caused by contraction and by bubbles, and these have on their walls or faces aboreseent growths, and on the surfaces of these growths I found microscopic crystals, composed of extremely thin transparent plates, having a high refractive power, and extremely hard, so that they scratched glass. The regular hexagonal form of these crystals led me first to suppose that they belonged to the regular hexagonal system; but on passing polarized light through them I was unable to detect any traces of polarizing power, and I am inclined to think, therefore, that these crystals belong to the regular system, and present the very common case of the distortion of the regular octahedron by the abnormal development of two of its opposite sides, by which a regular hexagonal plate may be produced. Similar distortion is frequently observable in alum and nitrate of lead. What this substance may be I am unable to state. I was able to collect but a very small quantity, and that under the microscope, with the aid of a needle. I have the specimens still sealed between glass plates, and I would gladly intrust them to any one who would undertake the analysis. Fig. 1 represents one such crystal, which cost two entire days' labor to secure, because it was necessary to suppress breathing while fishing for it, as the least current of air would blow it from the needle's point, and then it would be most difficult to find again. The crystals seldom occur isolated, but for the most part in groups, as in Fig. 2. In the places marked *a*, *d*, *h*, the crystals are heaped several deep, and of very indistinct and irregular form. In the spots *b*, *c*, *e*, *g*, on the other hand, there is but one layer, and it is clearly seen that they are six-sided plates. The dimensions given in Fig. 1 show how small the crystals are, but their thinness is still more remarkable, because, under a magnifying power of 550, it was impossible to measure their thickness. Fig. 3 represents a portion of the surface of the growth on the walls of the honeycombs, and on this is seen a kind of sweat or stream of a transparent substance, which may be the same as that which has been spoken of above, or may be different; it is not easy to determine. Fig. 4 represents the form of cavities caused by contraction or bubbles, in which I have often found the six-sided plates. Fig. 5 represents the appearance of the growths occurring in the central contraction cavities of cast ingots of hard steel. All these growths appear to have a smooth polished surface like that of a looking-glass. Fig. 6 represents the residuum remaining after dissolving steel in weak nitric acid. The substance remaining is probably silica; it is of a yellowish-brown color. The particles have the appearance of little plates, and a general appearance similar to the fracture of the steel dissolved. The study of such residuum is extremely interesting, and may lead to the elucidation of many problems concerning the structure of steel. Fig. 7 represents two grains appearing in the fracture of well-crystallized hard cast and unforged steel.

* 1875. A wagon axle treated in the above manner, and cooled in water, withstood twenty-two blows of ½ ton weight falling 14 ft., and remained unbroken.

NEW IRON-MAKING PROCESS.

THE members of the Manchester Scientific and Mechanical Society lately paid a visit to the Standard Iron and Steel Works Company (formerly Bolckow, Vaughan & Co.), Gorton, to inspect a new process for making iron and steel, patented by Mr. Samuel R. Smyth. About six or seven tons of common scrap-iron were melted in an ordinary cupola, and run into a Bessemer converter, the current of air from the blowing-engines being used to introduce certain chemical compounds and reagents into the molten metal for the purpose of eliminating impurities. This was done at a sacrifice of only a small percentage of iron. The process of refining and purifying occupied between nine and ten minutes, and the quality of the production appeared to be in every way satisfactory. Both gray and white iron can be produced of a high specific gravity and of great density. A number of test bars made by Mr. Smyth's process from gray iron were submitted for inspection. The cast-iron test bars were 1 in. square and 4 ft. 8 in. long, and at the time of testing were placed upon supports 4 ft. 6 in. apart. The weight was suspended in the centre on a knife-edge, the deflection measuring every 100 lbs. up to 600 lbs. The total deflection was found to be 1.375 in. The weights were then gradually removed, and when all were off the deflection was found to be about 0.002 of an inch only. The weights were again placed in the scale, and the deflection again taken. When 720 lbs. was registered the deflection was 2.078 in. The average breaking weight of five samples was 733.6 lbs. The material works as easily as ordinary cast-iron. Altogether the process seems likely to fulfil the sanguine expectations formed of it. The works have only been in operation a few days, and it is intended to erect an apparatus for making wrought-iron of high quality in large masses without piling or welding.—*Manchester Examiner.*

FLOUR MILLS IN THE UNITED STATES.

THE universal dependence of the human family upon bread as food has, no doubt, says the *Millers' Journal*, caused that article to be aptly designated as the "staff of life." It has been made of many substances, but in the American colonies, from the earliest times, Indian corn, wheat, and rye have been the leading, if not the only, materials. The laborers of Europe have only since comparatively recent dates used grain commonly for bread. The peasants of the south of France for long ages used only chestnuts and similar fruits for the purpose. In Germany rye forms the native "black bread" made of the grain ground but unbolted. The Scotch use oatmeal and barley for bread. The English use wheat commonly, as is the case now mostly in America. Here, however, the variety and abundance of animal and other food is so great that wheaten bread enters less into the daily diet of the masses than would otherwise be the case. Whatever the grain used, however, milling is the first necessity, and the number and capacity of the mills must always be proportioned to the numbers of the people.

In a country like this, where they multiply so fast, the investments in mill property must keep pace with the swelling numbers of the people. We find, therefore, in the returns of the manufacturing industry of the Union for 1850, published by order of Congress, that of the whole value produced, $1,019,106,616, by far the largest item was the products of flour and grist mills. This amounted to $135,056,736, or rather more than thirteen per cent. Next to this industry, the highest production was of cottons, the most general material for clothing, and that product reached $65,501,687. The largest mill interest was in the State of New-York, where the product was $33,037,021. The census of 1840 gave the number of flour-mills in the Union for that year, and if we compare the population and crop of wheat as reported, the results are as follows:

	Population.	Wheat raised. Bushels.	No. of Flour Mills.
1840.....	17,069,453	84,823,272	4364
1850.....	23,191,876	100,484,944	11,891
1870.....	38,558,371	287,745,626	24,100

We presume the number of flour-mills has also increased in a proportionate ratio. In order to get the quantity of wheat floured, it would be necessary to deduct from this production the quantity reserved for seed, and the quantity exported as grain. The result would show a diminished consumption for 1850 as compared with 1840. The crop of 1850 was, however, a short one, and was therefore not a fair representation of the national production.

From the earliest settlement of the country, flour has been an important article of export, and New-York wheat early gained a reputation as well abroad as at home. During the wars of Napoleon, the valley of the Hudson furnished large supplies of flour, and milling was a very profitable business. As the settlement of the country progressed, however, the supplies of wheat became greater, and the surplus produced above the wants of the people at times exceeded the export demand, and the mill interests fluctuated. Water power was that most generally used. Mills concentrated where this was to be had advantageously in the neighborhood of good supplies of wheat.

The mills of Rochester, N. Y., where the famous Genesee wheat is floured, are a grand example of well-applied water power. The Baltimore and Richmond city mills acquired great reputation, and of late years the settlement of the western country has caused St. Louis to become the central point of a vast region, and magnificent mills are there constructed. The mills at Louisville are also on a grand scale. One of those mills, as an illustration, erected at a cost of $80,000, has four run of stones of a capacity of 1500 bushels of wheat daily. Its packing arrangements are so complete that five hundred barrels may be turned out in a day. The mill is situated at the falls of the Ohio, just where they dash with irresistible force through the Indiana chute. The mill-race, excavated in the solid limestone, involved a large expenditure of time and money. The wheels are constructed on a new principle, being similar to the submerged propellers used in war steamers, and working an immense upright shaft, the base of which is sunk fifteen feet in the solid rock. This shaft drives the entire machinery of the mill with irresistible power and the regularity of clock-work.

Almost every state abounds in valuable mill sites that furnish the power for flouring the grain of the several districts for local use. Steam plays, however, an important part as a motor for supplying flour for export. The capital invested in flour mills in the whole country was, in 1850, given at $54,451,581, and the production $136,056,736. This, at the average value of flour, would represent 27,211,347 barrels, which would give an excess of 4,000,000 over the average consumption by the inhabitants. The number of barrels exported in that year was 1,385,448. The quantity of flour exported in 1860 was somewhat over 3,000,000 of barrels. To supply this and the wants of a population amounting in round numbers to 32,000,000, the quantity floured should have been at least 35,000,000 barrels, which should give a value, at the average price of the year, of nearly $210,000,000.

NURSERY FRUIT TREES.

VISITING the nursery of Messrs. Smith & Powell at Syracuse, N. Y., a few days since, some things, on going over the whole 500 and odd acres of nursery trees, struck me as novel and desirable to speak or write of. The collection of trees appeared to me most admirably estimated to meet public demands (by estimation I refer to the number of apple, peach, pear, cherry, plum, etc., to correspond with legitimate business); to me it showed universal judgment, but what else could we expect when we remember that Mr. Smith has been over thirty odd years in the practice of his present occupation. His son-in-law, and partner in business, Mr. Powell, has apparently a full mind and interest in the business, notwithstanding his love of the stock—especially horses—with which the farms, amounting in all to over 1,200 acres, can be grazed where the ground is not suitable for nursery trees, etc. One of the leading items I saw was fruit trees of varieties that had been successfully selected, taken up and replanted in regular blocks. These can be removed to an orchard almost without risk of failure, as each tree will have formed a mass of fibrous roots that, once again replanted, will connect with the soil and go on in the law of nature. This system, which the firm is pursuing, gives one a chance to renew his orchard when here and there a tree has died; and again it enables one to form a bearing orchard almost immediately, because this replanting not only forms new roots, but it helps to throw the tree into a state of maturity ere its regular time.

ROOT PRUNING OF EVERGREENS.—As I passed the evergreen rows of the nursery, I noted almost every row was of a more compact form than its neighbor. These trees, it seems, had all been root-pruned by means of a sharp root-pruning plough, so called, which a horse draws along upon each side of the row, and the pruner cuts not only the tap roots of the trees in the row, but also the side roots, causing the tree to make less elongated growth and more of compactness. Hedges four feet high can, by trees so managed, be made as fast as the trees can be transplanted, and look as regular and compact as if they had, under the owner's hands, received three or four years of culture and pruning.

HONEY LOCUST HEDGE.—Many years since I planted a honey locust hedge; said and wrote that it was the best hedge plant we had for this country. Here, upon Smith & Powell's grounds, I found blocks of thousands of one and two-year-old honey locust seedlings; and I saw a hedge nearly a mile long that, three years since, was planted with two-year seedlings, and is now four feet high and impervious to bird or animal. Let me urge all who plant hedges, especially as a fencing material, to use the honey locust. It never suckers and will last forever, and more, for all we know.

STOCKS.—We were especially interested in this visit to note the blocks of seedling stocks grown on suitable ground and for the use of the firm alone. Too many are careless in the use of stocks on which to engraft or bud the future tree, and little pieces of poor old sucker roots are often used, and the orchards of many who plant never give returns.

TWO BEAUTIFUL TREES.—On the homestead of Mr. Smith stands a Kentucky coffee tree, some fifty feet high, and beautiful in its rounded, upright form. This tree should be more often planted. As a street tree, it is one of the best. *Magnolia tripetala*, commonly called umbrella tree, and which is so fine in our southern climes, I found here in these home grounds 20 by 20 feet in height and breadth.

CHERRIES.—Passing through the nursery grounds, we came across labels of cherries. As every thing is plainly labelled on stakes, and a record of each block kept, no error of labelling can occur should the stakes be broken or stolen. Among these labels we found one called, by Prof. J. P. Kirtland, with whom it originated, "Elliott's Favorite." We confessed to having almost forgotten it; but when Mr. Smith said that, as a cherry for the amateur, it has no equal for flavor and richness, but it would not do for market, we coincided with him and remembered past days, when we stood hours under the Kirtland Seedling cherry trees, pencil and book in hand, and palate enjoying the fruit. Here we found also that Messrs. S. & P. grow Louis Philippe, a cherry that we have many times written of, and wondered it was not more known. As a bearer, it has no superior; as a tree, it is hardy, and as a fruit, both to eat and can, it is one of the best.—F. R. ELLIOTT, in *Country Gentleman*.

A B C PROCESS FOR TREATING SEWAGE.—NATIVE GUANO COMPANY.

By C. RAWSON.

THIS process derives its nam from the initial letters of the ingredients made use of, namely, aluminic sulphate, blood, clay, and charcoal, the three latter materials being specially intended to deodorize and purify the sewage waters, and the former to precipitate the impurities. An experience of over five years has proved that the A B C mixture removes from the sewage nearly the whole of its nitrogen, except that which is found in stale sewage in the form of free ammonia, and it even reduces this. In fresh sewage but little free ammonia is detected, and the other nitrogenous matters are precipitated in the native guano produced by the process. The little ammonia left in the effluent is in the form of sulphate of ammonia, and, therefore, as harmless as common salt. The process also removes from the effluent, and adds to the manure, every trace of phosphoric acid, a most important circumstance as regards the immunity of the effluent from future putrefaction. The effect of the A B C mixture is so instantaneous and complete, that from the moment it mixes with the sewage it is deodorized, and throughout the remainder of the process, even through the hot cylinder drying, or through many months' exposure in the open air, the deposit is entirely free from all nuisance; and the effluent water has been kept for years without any change of appearance or the least taint of smell, and that, too, without any filter being used or required. By the addition of a small quantity of carbolic sulphite (for the sole use of which valuable agent the company have made satisfactory arrangements), all living organisms and disease germs are effectually destroyed, and by the paralysis of organic ferments, subsequent putrefaction both in the effluent and in the deposit is entirely prevented. It has also been incontestably proved by many months' trial at Leeds, that the mixture of dye water and the refuse of many kinds of manufactories do not interfere with the proper working of the A B C process. Notwithstanding the mass of such impurities coming down daily at Leeds, the effluent continued for months, night and day, to run off in a clear transparent cascade, free from smell or color. Each chemical ingredient of the A B C mixture has its direct and intentional functions to perform, as follows:

When sulphate of alumina is brought into contact with sewage—a slightly alkaline liquid charged with nitrogenous organic matter—the alumina is separated in flocks, and by virtue of its remarkable affinity for dissolved organic matter, each particle seizes hold of and drags down with it a corresponding particle of nitrogenous impurity.

But the precipitated hydrate of alumina is light in character, and although it would ultimately settle, leaving a clear liquid above it, the slightest agitation causes it to float up, and thus renders it difficult on the large scale to drain off the mud.

The difficulty, however, is overcome by the introduction of the clay. This substance has a curious physical property; when finely ground up with water it forms a creamy emulsion which takes many days to settle, but on meeting with sulphate of alumina it, like albumen, coagulates and settles down, in heavy granular flakes.

Now in the process under consideration, the triple precipitation occurs at one time, and the three reagents becoming closely locked together, the heavy character of the clay gives density to the mass, and causes it to settle rapidly and remain in a compact form at the bottom of the tank. Any foul gases that may remain in solution in the water thus cleansed are attacked and rendered innocuous by the charcoal.

The purification process being completed, it remains to prepare the resulting manure for the market.

To the mud is added a small proportion of sulphuric acid, in order to prevent the loss of any free ammonia that may be present, and then it is dried in heated revolving iron cylinders, whence it issues in the form of an inodorous, inoffensive powder.

The process having been at work and under inspection for five years, the Native Guano Company claim to prove, by the testimony of many independent authorities, that it fulfils the four great requirements of any sewage process—requirements that must be fulfilled before success can be claimed, and by which every process should be tested.

1st. That the effluent is sufficiently purified to be innocuous and fit to go into a river.

2d. That this can be effected without creating any nuisance.

3d. That no material is used which injures or destroys the manurial qualities of the sewage.

4th. That it produces a manure capable of raising good crops of every kind, and that the value of such manure not only covers the expense of the process, but even leaves a satisfactory profit.

NEW CHALK FOSSILS.

THE shell coverings of marine animals remain intact for ages after the death of the creature to which they belong.

NEW CHALK FOSSILS.

Falling to the bottom of the body of water in which the animal existed, they become gradually buried by others of more recent date, and thus in the course of centuries great aggregations are formed, and, when the sea which covers them recedes, are found in a compact chalky mass, so that the history of the ancient world is written in chalk, one of the most important of geological formations.

A new field of investigations appears to open to researches during the cretaceous epoch, through the preparatory work of excavating the tunnel under the English Channel. There is no doubt that in the deep shafts to be sunk on each coast numerous fossils will be discovered, and by comparing those found on each shore a useful identity may be established between the strata which dip under the channel. The work therefore will be of the highest interest to geologists. It has already been determined that the isthmus between France and England was ruptured fully sixty thousand years previous to our era.

The annexed engraving represents a number of the curious new types of fossil shells found in cretaceous earth in France. Some of the shells are of great beauty, and their strange figures add to our knowledge of the creatures which filled the early oceans ages before the creation of man.

FREE SILICA TAKEN UP BY PLANTS.

IN our SUPPLEMENT No. 25 we published the interesting paper by Prof. P. B. Wilson concerning his discovery of the absorption of free silica by plants, as proven by the finding of diatoms on the stalks of wheat straw from a field that had been fertilized with what is known as Richmond or infusorial

DIATOMS OBSERVED IN WHEAT-STRAW.

earth. In the *Polytechnic Review* we find figures of some of the shells observed by Prof. Wilson, and also the following:

"My labors," says Prof. Wilson, "have been amply rewarded by one of the most enchanting views that has ever fallen to my lot to behold through twenty years of varied scientific investigations. When the epidermal silicious coating was adjusted upon the field of the microscope, some thirty-six forms of the diatomaceæ, which I have carefully sketched, were observed (see engraving) where perfect disintegration has been produced. When the structure to a great extent is retained, a marvellous interlacing of these forms presents itself, sometimes side by side, at other times overlapping.

"My mind was particularly impressed with the absence of the disk-like form, the *Actinocyclus ehrenbergii* and the *Actinoptychus undulatus* in their perfect state in the straw, while the other forms are common both to the infusorial earth and the wheat. My conclusions are that the varieties mentioned are too large to enter the root capillaries, for on the field of the microscope they have three to four times the magnitude of the others. This I will fully investigate, during the coming summer, by making accurate measurements of rootlets and diatoms, when I will be able to obtain stalks of wheat as grown in the fields, preferring this mode of investigation to *pot culture*, to disarm controversy, and to divest the investigation of all semblance of laboratory experiment.

"I have examined various specimens of wheat straw taken at random from the market, but have failed to find a single diatom. This to a certain extent surprised me, when taking into consideration that they are found to a limited extent in Peruvian guano. The inference to be drawn is that the soil was not fertilized by any material into which it entered as a constituent. I mention this to guide others who may make subsequent investigations from falling into error, in case occasional diatomaceæ are observed, as being derived from other sources than the infusorial deposits.

"These microscopic investigations show the absence of other forms of silica—that is, in granular particles in the (Kunkel) straw, they being entirely replaced by diatoms. This leads to the conclusion that the diatom is the more acceptable for assimilation, and when sufficient infusorial remains are present, replaces any other divided form of silica. I have previously attemped to substitute silica for diatoms, as obtained from the decomposition of slags from iron furnaces, but have failed to derive any satisfactory results."